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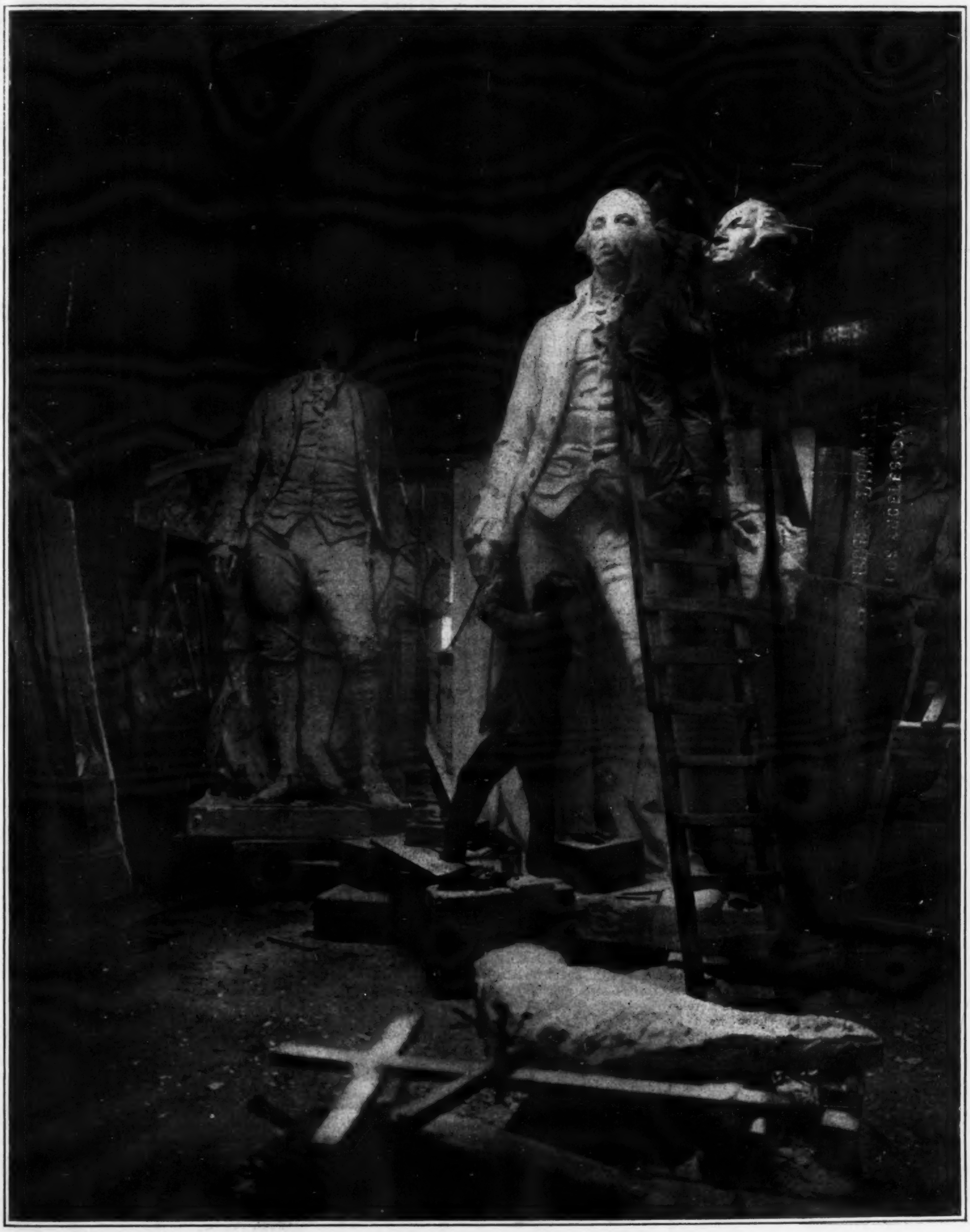

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Finishing the large figure of Washington for the Washington Arch in New York City.
MECHANICAL AIDS FOR THE SCULPTOR. **See page 288.**

Symbiotes or Benevolent Microbes and Vitamines

How They Assist in the Life Processes of Higher Organisms: A New Theory

By May Tevis

The world of science has recently been startled by a new and revolutionary theory concerning the so-called benevolent microbes. It has long been known, indeed, that the bodies of animals contain not only the pathogenic germs which produce disease, but other microbes which are apparently harmless. A well-known French savant, M. Paul Portier, professor at the Oceanographic Institute, has been studying these non-pathological micro-organisms for some years, and has recently advanced the novel hypothesis that they are not merely non-injurious, but are actually beneficial and indeed essential to the vital processes of higher organisms.

It is M. Portier's belief that symbiosis, *i.e.*, the life in common of two organisms which are mutually beneficial to each other, is a universal phenomenon. The classic example of this sort of communal life is the lichen, since every lichen is not a single plant, as it appears to be, but consists, in reality, of two plants, a fungus and an alga, which live together in harmony. According to M. Portier there are no simple organisms except bacteria, all the higher organisms being in reality twofold, consisting, that is, of the organism itself and of the micro-organisms which are distributed throughout its tissues and play an important and necessary part in the processes of life.

To these minute collaborators in the vital functioning of the organism the name symbiotes has been given. These symbiotes, which are very plastic and very active have been isolated and proven to be capable of life outside their host. While widely distributed throughout the body they are found principally in certain organs, particularly in the pancreas and the reproductive glands; they rarely occur in the liver.

During the last year or so M. Portier has published several memoirs concerning his studies of symbiotes in the *Comptes Rendus* of the French Academy of Sciences and elsewhere. Furthermore he has just published a volume entitled *Les Symbiotes* (The Symbiotes), in which he gives voluminous data concerning his experiments with a large variety of animals, ranging from insects to vertebrates, along this line. We are greatly indebted for the information in the present article to an admirable review of the latter from the pen of Henry de Varigny, which appeared recently in the *Bibliothèque Universelle* (Lausanne), since the work in question has not yet reached this country.

M. Portier gained his first idea of symbiotes through the study of certain caterpillars of the micro-lepidopters, such as the genus *Nepticula*. These caterpillars inhabit minute tunnels which they excavate in the thickness of leaves. They are absolutely aseptic and live upon crushed plant cells whose content is accessible to the digestive juices. Other caterpillars, such as that of the *Gracilaria Syringella*, are also aseptic at the beginning of their existence before they desert their tunnel to live outside. Living then upon more resistant cells they crush them imperfectly. But upon quitting their tunnels they become infected and their digestive canal is full of microbes living upon cellulosic débris which they render soluble. Here we have the beginning of a beneficial association since the microbes live upon the cellulose while the insect lives upon the contents of the cells liberated by the dissolving of the cellulose. Again the digestive juice of those insects which live upon wood (xylophagic) is not capable of attacking cellulose, yet the larvae are enabled to develop by means of microbes which live upon wood by means of cytolysis afterwards supporting the life of the larvae. In the caterpillars of *Nonagria* and of *Sesia*, these well-fed microbes penetrate the epithelial cells of the intestines and there become liquefied; there is an intercellular digestion of the microbe by the intestinal cell. Some of them pass into the blood, where they are intercepted and absorbed by the leucocytes or white blood corpuscles, while some of them escape this fate and become encysted in the tissues. They pass of their own accord into the eggs and there multiply, and when the egg develops the larva is already provided with its symbiotic micro-organism. Thus in this case symbiosis is actually hereditary, and this seems to be intentional upon the part of Dame Nature, since the tissues which contain the most of these auxiliary microbes are the reserves of fat adjoining the reproductive glands. These inclusions exist in all insects and have also been found in all vertebrate animals thus far investigated.

M. Portier has even succeeded in cultivating the symbiotes found in vertebrates, the easiest cultures to make being those from the lower forms of vertebrates. He has established the fact that the symbiotes of birds and mammals require a temperature of about 40°C., while for those of the lower vertebrates 25°C. is sufficient. It has been proved that the culture takes place through the skin which develops upon the surface, but it is evident that the passage of the tissue into the midst of the culture constitutes a critical period for the symbiote which it does not always survive. A curious circumstance is that the best culture of symbiotes is yielded by a tissue which has just passed through a state of intense physiological functioning.

As seen in the culture the symbiotes are highly polymorphous. They are generally in the form of bacteria of medium length, but by varying the culture medium they can be transformed into short bacilli and even into ordinary micrococci or into large spherical micrococci—or again into highly mobile short bacilli or into immobile filaments. All these are reduced to fragments by the presence of antiseptics. Thus we see that they are highly malleable from the morphological point of view.

They are equally malleable likewise from the physiological point of view. The optimum temperature varies according to the origin. When the symbiote is derived from a frog or a toad, 25°C. is a sufficiently high temperature, while from 42°C. to 45°C. is required when it comes from a mammal or a bird. Thus we see that it produces races which are adapted to the heat of the surrounding medium; however, all symbiotes of whatever origin are capable of adapting themselves to both these extremes and even to temperatures of from 50°C. to 60°C. (122°F. to 140°F.).

In spite of this comparatively great resistance to heat, symbiotes perish ordinarily when in a moist medium at less than 100°C. However, they can be trained so as to resist a temperature of 110°C., or even 117°C. In the dry state they will resist 140°C., but at 150°C. they do not survive more than half an hour.

All antiseptics are fatal to them, the amount and time required being variable. If such experiment be arrested before death ensues symbiotes are obtained whose culture is slower and more difficult and an aberration of form is exhibited.

HOW SYMBOTES ASSIST IN NUTRITION

M. Portier is convinced that symbiotes preside over two sorts of phenomena in the process of nutrition—simplification and destruction on the one hand and building up or synthesis on the other. When furnished carbohydrates they render them very oxidisable reducing Fehling's liquid just as the organism does. They transform glycerine into dioxyacetone; they seem, indeed, to transform proteic substances into acid amines in the same manner as does the organism. From the synthetic point of view they also behave like the organism, since when furnished with saccharose and a nitrate they manufacture a polysaccharid which is very similar to glycogen. As a matter of fact, according to M. Portier, it is really the symbiotes which accomplish this work and not the organism itself.

So far as is now known the symbiotes probably enter the organism with food by way of the alimentary canal. When inoculated experimentally subcutaneously or into the circulatory system they are entirely innocuous, producing no reaction.

One of the most important features of the author's theory is his identification of the symbiotes with the elements of the cell known as mitochondria. These are minute bodies which exist in all cells whether of animals or plants except in most of the bacteria. They are also known as bioplasts, leucites, vesicles, etc. They are usually in the form of small spherical bodies, but sometimes occur as filaments composed of grains, or even as rod-like bodies. M. Portier is convinced that these mitochondria, a definite number of which exist in each cell, are really symbiotes.

Various investigators have differed greatly as to the function of the mitochondria. Thus Guillermond has shown that they elaborate starch; Policard, that they produce hemoglobin; Mulion, that they make pigment, etc. M. Portier harmonizes these discrepancies by declaring that the mitochondria are really symbiotes—independent organisms feasting at the same table with higher organisms. The symbiote, in other words, is a highly polymorphous form of bacteria.

Certain histologists raise the objection that the mitochondria are not always capable of being cultivated *in vitro*. The author of this theory answers the said objection in a highly ingenious and interesting manner. He observes that there is no more reason why the mitochondria should be able to reproduce themselves at all times than for men or animals to possess the same prerogative. In men and animals old age causes the loss of reproductive powers, while in the mitochondria the same result is occasioned by the fulfilment of their physiologic rôle. When a mitochondria elaborates any product whatever it becomes a sac containing the said product. In this condition the mitochondria loses its power to reproduce itself by division and remains a mere envelop. The mitochondria which reproduces itself is the one which has not yet become specialized.

* * *

Vital operations are of two sorts—functional activity involving the destruction of reserve material and the liberation of energy and functional repose during which the reserves are elaborated by means of synthesis; as Claude Bernard has strikingly expressed it: "Life is creation." Both these phenomena occur alternately in the same cell and in the same symbiote according to M. Portier—but the symbiote not only manufactures a food reserve but is totally transformed into such an aliment and is entirely consumed at the proper time. The symbiotes share with their sister bacteria an enormous power of synthesis of the most complex and various substances. Bacteria are even capable of manufacturing protoplasm, albumenoid matter from simple inorganic substances, while, on the other hand, there seems to be no organic compound in nature which cannot be disintegrated into its elements by some sort of bacteria.

M. Portier's view as to the part played by symbiotes can be best understood by studying concrete examples. There are certain living creatures, namely, the bacteria, which are sufficient to themselves in the matter of nutrition. Hence they may be termed *autotrophic;* these possess neither symbiotes nor mitochondria—they are themselves symbiotes or mitochondria and derive from inorganic matter the material from which to manufacture organic matter, namely their own protoplasm. All other living creatures, whether plants or animals, contain symbiotes and are, therefore, termed *heterotrophic*. With the exception therefore of bacteria all living organisms present a condition of symbiosis.

What then is the rôle of the cell? In the first place it appears to limit the number of symbiotes contained. Furthermore, it appears to constitute by means of its cytoplasm and its nucleus the chemical milieu which surrounds the symbiote and from whence the latter extracts the raw material required for its activities.

SYMBOTES AND VITAMINES

A highly interesting point with respect to vitamines is raised by M. Portier, which will undoubtedly rouse wide interest and possible controversy among men of science. It is only a few years ago that the well-known English scientist, Caspar Funk, made the startling announcement that certain wasting diseases, such as scurvy, beri-beri, etc., are really maladies of malnutrition and are due to the lack of certain indispensable elements in the food of the victims of such diseases. These elements were termed *vitamines* by Funk. These vitamines are supposed to exist in certain portions of fruit, seeds and vegetables more than in others. Thus they are contained in the outer coatings of rice, wheat and other cereals and for this reason polished rice and white flour (made from the inner part of the wheat) are imperfect

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food, incapable of supporting life unless supplemented by other foods containing the vitamines, i.e., certain acid amines which are indispensable to life, of which the former have been deprived. But Portier holds the opinion that such maladies are really due to a deficiency of symbiotes, or what he calls a state of *a-symbiosis*. According to Funk the sterilization of foods, as in canned vegetables, kills the vitamines, and for this reason such foods tend to produce scurvy. But according to Portier sterilization kills the symbiotes. He has proved by experiments that the latter perish at a temperature of about 120°C. and he points out that this is the very temperature at which vitamines are supposed to be destroyed, remarking that it is much easier to believe in the death of the living organisms known as symbiotes than in the disintegration of a vitamine, which as a matter of fact has been proved not to dissolve until the temperature of 233°C. is attained.

One of Funk's most convincing experiments was the feeding of mice with bread which had been previously treated with alcohol. When fed upon this bread alone the mice soon died, but when the alcohol in which the bread had been soaked was added to the bread the mice continued to thrive. Funk explains this by saying that the alcohol has absorbed the vitamines and carried them away with it. Portier declares in his turn that the alcohol has removed the symbiotes. The latter are found abundantly in bran, and if the bran be treated with alcohol and the alcohol then evaporated the residual liquid will produce an abundant culture of symbiotes. Symbiotes resist alcohol and also resist heat up to 120°C. One of Funk's most telling arguments is that the decortication of rice and other cereals occasions phenomena of malnutrition, which he ascribes as we have said, to the removal of the vitamines, but Portier claims that the phenomenon is due to a lack of symbiotes. Living symbiotes are found in bran and in the integuments of seeds in general. But in the seed they have already been transformed into sacs containing reserve products, and if an animal is given cereals deprived of the coatings of the grain, it is given a food lacking in symbiotes.

But Funk was able to restore pigeons suffering from polyneuritis through de-vitaminized food by administering to them vitamines in the form of a crystallized substance and this substance contains no symbiotes. Portier, however, responds gallantly to this argument by saying that doubtless the vitamine is one of the products of the activity of the symbiote. The same restorative result can be obtained, therefore, by administering either vitamines or symbiotes to the victim of malnutrition. As a matter of fact this view appears to be supported by a striking experiment made by Portier and Bierry. They injected living symbiotes into animals in a state of a-vitaminosis, i.e., almost at the point of death through malnutrition. The animals were immediately resurrected exactly as when vitamines are injected.

* * *

It has long been acknowledged that certain plants such as the leguminosae possess symbiotic bacteria and that these assist them in obtaining their proper nutrition. It is but a step further, therefore, to suppose that analogous bacteria, or symbiotes, may have a like function in the nutrition of animals. It is supposed that the symbiotes enter the alimentary canal of men and animals together with their food and the question then arises as to the method by which they become distributed in the various organs where they are found. M. Portier's theory is to the effect that this distribution occurs by means of the blood. It has been shown in recent years that besides the red corpuscles and the white cells, or leucocytes, the blood contains certain minute bodies termed globulins, whose origin and function has never been ascertained. These globulins exhibit a striking resemblance to bacteria. They are in the shape of rods of different sizes, as if some of them were older than others. These rods readily assume the rounded coccus form quite like the mitochondria; they are most numerous in those creatures whose metabolism is most intense. They are markedly diminished in a state of fasting. Portier has conceived the idea that these globulins are really symbiotes employed in the nutrition of the animal.

Granted that the symbiotes are concerned in nutrition the question naturally arises as to whether they play their part in reproduction. A distinguished histologist, Fauré Fremiet, has shown that the ovule is almost entirely lacking in mitochondria while the corresponding male element is well supplied with them. Portier explains this by saying that the mitochondria or symbiotes in the ovule have already undergone a transformation into reserve materials, usually fats, as described above. It will be remembered that there are numerous cases of natural or artificial parthenogenesis, in which the ovule develops without being fertilized. The development starts from a mass of matter called by histologists the *vitelline body*, which is of mitochondrial origin. But according to Portier this vitelline body consists of a cluster of symbiotes which have become isolated but are not yet transformed into sacs of reserve materials. These symbiotes when set free by a process which remains to be discovered are capable of producing the development of the ovule in spite of the absence of male element which is so well supplied with symbiotes. It will be seen that this hypothesis supplies an explanation not only for natural, but also for artificial or experimental parthenogenesis, if we suppose that the ovule contains a sufficient number of non-transformed symbiotes to replace those which are habitually introduced by the male element. If this be true the experimenter need only arouse by some suitable agent the symbiotes which exist therein in a quiescent state, or else to innoculate the ovule with fresh symbiotes if those already existing therein are exhausted.

* * *

One advantage of the theory of symbiotes, according to its author, is that it agrees admirably with the "*Unicist*" theory of life. The view was held by Liebig and J. B. Dumas that the nutrition of animals differs in nature from that of plants, the latter making use of immediate principles by means of synthesis and reduction while animals destroy and oxidise the materials elaborated by vegetable life. In other words the animal merely makes use of building blocks which have been constructed by plants from inorganic matter. This theory was vigorously combated by Claude Bernard, in whose opinion analysis and synthesis are inseparable—the two phenomena being co-existent in all living organisms. This view is termed the Unicist theory. The intervention of symbiotes, "which are derived from the same stock and which are, perhaps, identical, or which at any rate consist of very similar species in all living creatures," says Portier, well accords with the views of the great physiologist.

* * *

If symbiotes wear out and grow old through their activities and their transformations and if they are indispensable to the organism, it is evident that the latter cannot survive unless the supply of young symbiotes is constantly renewed from without; hence if the food fails to contain the necessary supply of symbiotes the organism is in jeopardy, a view which accords with what has already been said concerning vitamines and symbiotes.

Animals fed upon aseptic food which has not been heated thrive perfectly; they also thrive upon food which has been slightly heated, even when the heating has been repeated several times, provided the temperature is not too high. But as soon as the temperature of boiling water is reached some foods become injurious, while all are harmful after being heated to 120°C. (248°F.). In other words a food which has been certainly sterilized by heat is a food which may still retain its physiological, but not its biological value. M. Portier believes that it is the destruction of the symbiotes which has thus depreciated the value of the food. The aseptic life is possible when symbiotes are present, as in the case of the tunnel-making caterpillars referred to above, but is impossible without symbiotes. But it must not be forgotten that the symbiotic condition is a state of normal physiological association, which should not be confused with the septic condition which is a state of abnormal and pathological association.

It has been proved, however, that certain animals exist which are capable of living upon food which is entirely free from symbiotes. Portier explains such apparent exceptions by saying that in all cases where the organism seems to feed upon aliment which are deprived of symbiotes, it is nourished in reality by a "transformator" which intervenes between the feeder and the food—usually by a fungus which contains symbiotes. There are certain coleoptera which live upon the wood of trees in which they excavate tunnels having a characteristic form. Apparently they live upon the wood itself, which is lacking in symbiotes. In reality, however, it is a fungus of the genus *Ambrosia* which lives upon the wood, and this fungus contains symbiotes. The wood which is indigestible for the insect is digested by the fungus, after which the insect feeds upon the transformator fungus. Another example is of the termite, which stores up in its hill dead wood which it crushes and swallows. It seems to live upon the wood, but this is accomplished in a very curious manner. It collects its own excreta and agglomerates them into spherical granules, forming a sort of cake. When these cakes are examined minutely they are seen to be filled with the mycelium of a fungus which produces spores here and there. In an occupied ant hill only this mycelium is seen, but in a deserted hill there issues from the mycelium a sort of down 4 or 5 mm. in height. The fact is that the ants graze, so to speak, upon this growth, and thus keep it cut short. In reality, therefore, they swallow the wood merely to prepare a suitable soil for the fungus, which is their actual food supply.

Even more curious is the case of the wood-eating caterpillars of the genera *Cossus*, *Sesia*, *Nonagria*, *Zeuzera*. These do devour wood indeed, but when the ligneous paste in the alimentary canal is examined it is found to be filled with micro-organisms, particularly with the conidia of a fungus of the genus *Isaria*, and it is the spores of this fungus which form the food of the insects. These spores, which contain symbiotes, are absorbed by the epithelial cells and the leucocytes. There are even cases in which the intermediary fungus is cultivated neither outside the animal nor in the alimentary canal, but in its very tissues. An example of this is the ordinary aphis or plant louse. This seems to suck the juices of the plant which it pricks. However, it sucks them in through a sort of filter, through which it is impossible for symbiotes to pass. But M. Portier explains that the aphis possesses two lumps of a brown or green substance at one side of the intestine, which are filled with bacterioidal bodies which form a mycetome, i.e., a mass of yeast cells. The nature of this green mass has been much debated. Portier considers it merely a collection of symbiotes—a fungus living upon the juices drawn from plants and provided with symbiotes. It is this fungus, he believes, which is the real food of the lice; the latter suck the plant juice to nourish the fungus, which in turn nourishes them.

SYMBOSIS IN PLANTS

Certain plants also exhibit a state of symbiosis. The seeds of orchids, entirely lacking in the reserves of alimentary substances for the young plant, which most seeds contain, are incapable of germination when sown upon sterile ground, but readily germinate upon soil where orchids have previously been cultivated for the reason that in this case the teguments are invaded by a fungus of the genus Rhizoctonio. The cells of the orchid digest the mycelium of the fungus and Portier, therefore, regards the orchid as being epixylous in a manner similar to the cytases which attack the wood; it develops by feeding upon the nutritive matters thus elaborated and it then becomes a source of food supply for the plant, to which it gives over the symbiotes. In the orchid this symbiosis is usually not hereditary, i.e., the symbote does not exist in the seed as it exists in the egg of xylophagous animals—nature relies upon the symbiotes of the soil to supply the seed. In the *Neottia*, however, the parasitic fungus passes into the seed. Similarly the mycorhizes of many plants merely represent a case of the symbiosis of a fungus and a plant of higher order.

SYMBOTES AND DISEASE

It will be remembered that the minute bodies in the blood known as globulins are looked upon by Portier merely as circulating symbiotes. If this be true it is possible that they take part in the defence of the organism through the production of immunity. A number of recent researches has shown that the globulins are probably concerned in the genesis of alexine and of the anti-bodies and also in the elimination of bacteria, especially staphylococci. It has been observed, too, that in a condition of anaphylaxia, i.e., the partial or total incapacity of the organism to react against the introduction of injurious substances, the globulins are almost entirely lacking, and it is suggested that if some means can be found to increase the multiplication of the globulins infection may thus be combated.

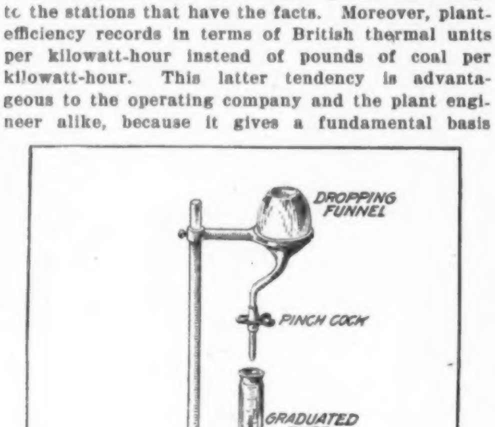
We will not here discuss Portier's theory of the possible connection between symbiotes and cancer, since much more work along this line is needed either to substantiate or to disprove his views. In the same way the hypothetical connection between symbiotic action and the sudden variation of species known as *mutation* though provocative of interest can here be merely mentioned.

Coal Analyses Made at the Power Plant*

A Simple Method that does not call for the Services of an Expert

By E. D. Hummel

Coal analyses are rapidly becoming a necessity in power plants because the best grades of coal go to the stations that have the facts. Moreover, plant-efficiency records in terms of British thermal units per kilowatt-hour instead of pounds of coal per kilowatt-hour. This latter tendency is advantageous to the operating company and the plant engineer alike, because it gives a fundamental basis



Some of the apparatus required

for discussing efficiency upon which there can be no misunderstanding. The practice would no doubt have grown faster had it been easier to make proximate analysis of coal. The chief reason for making the coal tests at the plant, however, is that the results can be secured in a few hours after the sample has been received, whereas it may be a matter of days if samples must be sent to a chemist. Getting the data thus promptly permits the engineer to work up operating results based on actual tests of the coal fired instead of results based on analyses of coal handled a week previously which was supposed to be the same. Many plants use the latter method, but there are cases where the results so secured have been found to be misleading.

It is usually considered that a chemist is required to determine the number of B.T.U. in a pound of coal Modern apparatus, however, renders this determination relatively simple, much more so than the average engineer realizes. In fact, the work can be outlined in such a manner that the layman can handle it. The following article describes a simplified method of analysis in power stations to determine the quality of the coal used without sending it to a laboratory.

A manipulator does not have to be a skilled chemist to make a proximate analysis of coal by this method. Any person who is able to calculate, to take temperatures and to weigh, and who possesses a fair degree of common sense, may obtain good results after a little practice. Practice and accuracy in taking readings are the prime factors in getting a final result that may be relied upon.

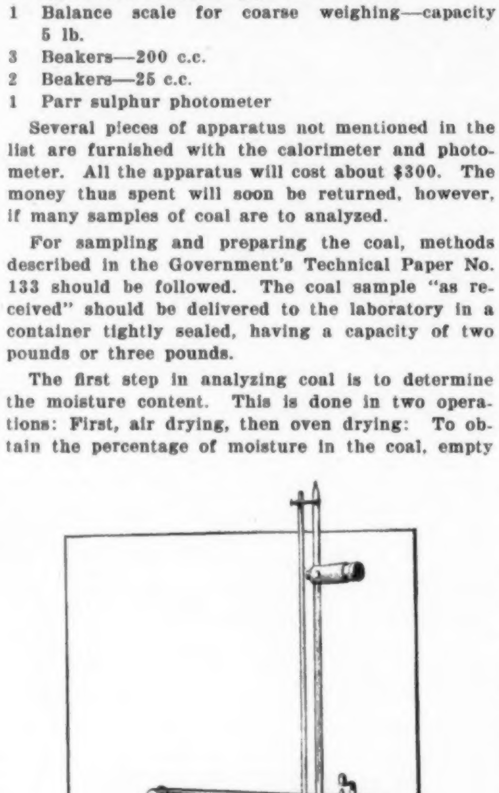
The following is a tabulation of apparatus required to equip a power station laboratory for the purpose of analyzing coal.

1 Parr standard calorimeter
1 Electric stirring motor—specify whether to be used with 110 or 220 volt d.c., or 110 or 220 volt a.c.
1 Bank of resistance for 110 or 220 volts
1 Hot-air oven
1 Thermometer 0—400 deg. F. for oven
1 Mortar and pestle
1 Balance scale—Becker or equivalent
1 Set of metric weights
1 Desiccator, 6 or 8 in.—Sheibiers or equivalent
1 Bunsen burner
1 Support
4 25-c.c. porcelain glazed crucibles
2 Steel spatulas
1 Crucible tongs
3 2½-in. iron triangles—pipe stem covered
1 Balance scale for coarse weighing—capacity 5 lb.
3 Beakers—200 c.c.
2 Beakers—25 c.c.
1 Parr sulphur photometer

Several pieces of apparatus not mentioned in the list are furnished with the calorimeter and photometer. All the apparatus will cost about $300. The money thus spent will soon be returned, however, if many samples of coal are to analyzed.

For sampling and preparing the coal, methods described in the Government's Technical Paper No. 133 should be followed. The coal sample "as received" should be delivered to the laboratory in a container tightly sealed, having a capacity of two pounds or three pounds.

The first step in analyzing coal is to determine the moisture content. This is done in two operations: First, air drying, then oven drying: To obtain the percentage of moisture in the coal, empty



Calorimeter ready for test

the contents of the container on a square of stiff paper which has been previously counterpoised and weigh it. Allow the coal to stand in a current of air warmed to from 80 deg. to 100 deg. F. for a period not less than twelve hours. Then weigh it and compute the percentage of moisture by this formula:

$$\frac{\text{Weight moist coal—weight dry coal}}{\text{Weight moist coal}} \times 100 = \text{Percentage of moisture} \qquad (1)$$

When the sample lot has been reduced by quartering to about 1 oz. to 1½ oz., grind it in the mortar until it will pass through a 100-mesh sieve. This must be done rapidly to avoid any loss of moisture during the process.

Weigh out 5 grams of the powdered coal and put it in a 25-c.c. crucible. It is well in doing this to counterpoise the crucible on the balance and weigh the coal directly in the crucible, thereby eliminating any loss of coal by transferring it from the balance pan to the crucible. Dry it in the oven for one hour at 220 deg. F. After this, cool it in the desiccator and weigh it. The loss indicates the amount of moisture in the air-dried coal. To calculate the percentage of moisture use formula (1).

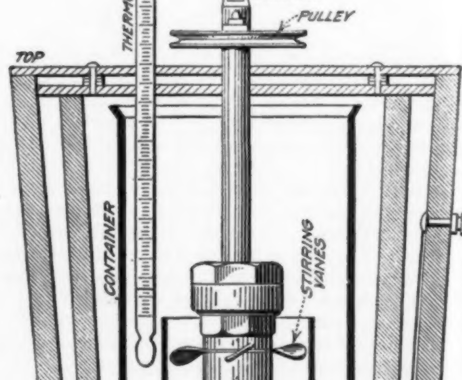
VOLATILE MATTER ALSO DETERMINED BY HEATING

To determine the amount of volatile in the coal, weigh out one gram of the powdered coal in a 25-c.c. crucible after counterpoising the crucible. A platinum crucible is preferred, but one of porcelain will do. The volatile determination is similar to the moisture determination, but is made with the temperature at red to white heat and with the careful exclusion of air. If the coal is not very moist, as is the case of oven-dried coal, it is necessary to wet it slightly after weighing it in the crucible. This allows the air to be expelled from the crucible and prevents the oxidation of the coal. A piece of asbestos paper somewhat larger than the top of the crucible can be used between the edge of the crucible and the lid. This, being weighted down, acts as a check valve allowing the gas to pass off, but preventing the ingress of air.

When these preparations have been made, heat the crucible with a bunsen burner capable of raising the temperature to a white heat. Heat it slowly for the first five minutes while expelling the air, then heat it to the limit of the burner for 15 to 20 min. It is well to have a metal chimney around the flame to avoid the effect of drafts of air. At the end of the heating period cool the test sample in a desiccator with the lid on. When it is cool, remove the lid and inspect the contents of the crucible to determine the coking power of the coal. Weigh and calculate the percentage of volatile matter by formula (2).

$$\frac{\text{Weight of residue}}{\text{Weight of coal}} \times 100 = \text{Percentage volatile.} \qquad (2)$$

The process of ash determination is somewhat like the process of finding the percentage of volatile matter. The first step is to weigh out one gram of the powdered coal in a 25-c.c. crucible after counterpoising and weighing the crucible. Then place the crucible about three inches above the flame of a bunsen burner, the flame being about three inches in height. Allow it to remain in this position for 15 min. to permit the volatile matter to pass off, then lower it well down within the flame, leaving it in this position until observation shows a clean ash. This observation is important as the ash determination is very slow when the coal is burned in the open, depending on the atmosphere for the supply of oxygen. Cool it in the desiccator and weigh it. Calculate the percentage of ash by formula (3).



Section of coal calorimeter

$$\frac{\text{Weight of ash}}{\text{Weight of coal}} \times 100 = \textbf{Percentage ash.} \qquad (3)$$

* From *Power*.

To find the percentage of fixed carbon, subtract from 100 per cent. the sum of the moisture, volatile and ash percentages.

Determination of the heating value is made by a Parr standard calorimeter. In preparing the charge, weigh out one-half gram of the oven-dry coal. In transferring the coal from the balance pan to the fusion cup great care must be exercised not to lose any particles of coal. Before transferring the coal to the fusion cup, see that it is clean and dry. Weigh out one gram of accelerator ($KClO_3$). If the accelerator is lumpy, it must be pulverized on a piece of glass with a spatula, preferably before weighing. Transfer the accelerator to the fusion cup with the coal Then close it with the false cap and shake it vigorously for five minutes to insure a positive mixture. After it is well mixed, add one full measure of sodium peroxide (NA_2O_2), using the measure furnished with the calorimeter.

In filling the measure it should be tapped to insure complete filling. This must be done rapidly as the peroxide will absorb moisture. In adding the peroxide to the contents of the fusion cup, incline the fusion cup slightly to avoid blowing out the particles of coal. When the peroxide is added, close the cup again with the false cap and shake it, using the same precaution to get a good mixture. After it is well mixed, tap the false cap to remove all particles of the mixture from the upper part of the cup. Then prepare the ignition stem by attaching a piece of fuse wire about 2.7 in. (7 cm.) long to the terminals, passing it through the eyelets. Tighten it to insure good contact, allowing the loop to extend from three-eighths to one-half inch below the central terminal. Remove the false cap from the fusion cup and replace it with the ignition stem. Place the floating bottom at the lower end of the bell-body; place the fusion cup in the bell-body and insert the ignition stem; screw it down tight with the two wrenches. Put on the stirring vanes, allowing the small holes near the lower edge of the bell-body to be exposed. Remove the can from the calorimeter and fill it with 2 liters of water, preferably distilled. This water should be at a temperature of one or two degrees below that of the room. The room temperature should be, if possible, about 70 deg. to 80 deg. F., in order to keep well within the range of the thermometer. Place the container and top in place and see that the thermometer extends a little over halfway to the bottom of the container. Place the pulley in position on the stem, which should then be connected by a light flexible cord to the motor. The stirring is effected by the vanes on the bell-body. The pulley should be revolved in a clockwise direction at about 150 r.p.m. Set the switch, being careful not to allow it to touch the ignition stem until the proper time. Allow the unit to revolve a few minutes before taking readings on the thermometer. Take the readings one minute apart for four or five minutes before igniting the charge, to insure an equalization of the temperature. To ignite the charge it is well to throw in the switch with a long stick to insure safety. After igniting the charge the temperature should begin to rise immediately. Take readings at one-minute intervals for nine or ten minutes. The readings must be carefully taken. If the temperature of the water before igniting is one or two degrees below room temperature, the temperature at the end of the first minute after ignition will be something over the room temperature and the radiation for that period may be considered self-correcting. Ordinarily, the rise in temperature will continue for four or five minutes, at which time the maximum will have been reached.

HOW TO FIND THE RADIATION

The radiation for this period is found as follows: Read the fall of the temperature for each minute for four or five minutes after the maximum has been reached. The average drop per minute represents the correction to be added to each minute preceding the maximum, except the minute immediately following the ignition. The final temperature thus corrected for radiation minus the initial temperature of the water represents the total rise in temperature.

From the total rise in temperature, corrected for radiation, subtract the correction factors for heat due to chemicals, fuse wire, etc. These correction factors are given in one of the tables . Then multiply the remainder by 3100 (the constant on the calorimeter). The product will be British thermal units per pound of coal.

It should now be noticed that the heat value of the coal as derived, refers to the coal in the condition in which it was weighed out for making the determination. That is to say, if coal having 14 per cent. moisture is oven dried before weighing out the portion for the calorimeter, the determination is for dry coal. To reduce this calculation to an "as received" basis, divide the number of B.t.u. obtained by 100 per cent, plus the percentage of moisture present in the coal obtained by determination.

TABLE OF CORRECTION FACTORS FOR CALORIMETER

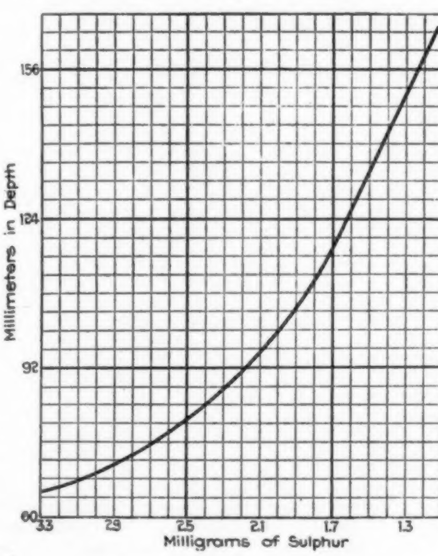
	Deg. F.
Percentage ash, multiplied by	0.005
Percentage sulphur, multiplied by	0.010
Fuse wire	0.005
Accelerator, 1 gr.	0.270
Hydration, bituminous coal	0.070

SULPHUR CONTENT FOUND BY PHOTOMETER

Determination of the percentage of sulphur in coal can be made by a Parr photometer. To obtain the sulphur content by this method, the residue from the fusion cup of the calorimeter is used. The first step is to place the material from the fusion cup in a large beaker after the cartridge is dismantled and pour hot water over it. In all add about 150 c.c. of water. Heat the mixture for five to ten minutes, then cool it and add enough pure concentrated hydrochloric acid (HCL) to neutralize the solution. Then add 5 c.c. of acid in excess.

Transfer the slightly acid solution to the 250-c.c. flask and fill it up to the 250-c.c. mark with pure water. Mix it thoroughly and then measure out for the analysis 25 c.c. of the solution in a graduated tube having a capacity of 100 c.c. Fill it up to the 100-c.c. mark with pure water. Transfer the 100 c.c. of solution from the cylinder to the Erlenmeyer flask and add 0.3 to 0.5 gram of barium oxalate powder, and without delay close the flask with the cork and shake vigorously for three to five minutes. Then allow it to stand for fifteen minutes.

To secure the turbidity, the solution is shaken



Sulphur photometer curve

and poured from the flask to the dropping funnel. The graduated tube is adjusted in the dark so that the rounded end dips well into the water in the flat dish, which should be about one-half inch in depth. Adjust the flame to a height of one inch; this is accomplished by having the flame appear one-eighth inch above the metal chimney.

By means of the pinch-cock admit the solution until the point of light from the candle flame just disappears; that is, until the last point of light from the flame is no longer visible.

Remove the tube and read in millimeters the depth of the liquid. By means of the curve shown herein, the milligrams of sulphur in the 100 c.c. of solution is determined. If 25 c.c. were taken from 250 c.c. before the light is observed and this later contained the fusion from ½ gram of coal, then the sulphur reading would be the weight present in 1-20 gram of coal.

If, for example, the result shows 90 mm. in the tube there would be indicated 2.24 mg. of sulphur present in the quantity taken; that is 0.00224 gram. If one-half gram of coal is represented in this amount, there would be 0.0448 gram of sulphur, or 4.48 per cent., in the coal.

Special care should be taken to prevent the settling of the precipitate. A reading should be taken quickly and the contents poured back into the dropping funnel. Readings should be repeated several times to afford greater accuracy in the final average.

Light and Color in Relation to Stage Effects.*

There are few, if any, stages in this country really well lighted, yet the importance of proper stage lighting can scarcely be overestimated. The relative values in order of importance are: First, the play; second, the acting; third, the lighting; fourth, the scenery; and fifth, the dresses. Stage lighting may be defined as the are of placing or graduating, and of coloring light and shade.

The theatre, like other arts, was originally associated with religion, and in the early stages of their evolution religious ceremonial and dramatic representation are closely associated. Historically the value of lighting was appreciated as early as A. D. 750 at the Byzantine Court, and in 1160 we find sconces of candles used in miracle plays, flares and squibs especially being employed to give local color to the devils. It was not until 1556 that Edward VI. granted his players a definite structure in which to produce plays, and half a century later saw the birth of the Elizabethan drama. Yet artificial lighting was practically unknown in England until 1682, when Sir Christopher Wren built the first theatre, Drury Lane, and Inigo Jones contrived the stage mechanism. Candles were then used, and a "patent stage lamp" invented in 1785. At the Lyceum the æsthetic value of lighting was first completely studied.

To-day stage lighting is both a craft and an art, calling both for æsthetic perception and engineering skill. In the ordinary theatre light is still used in substantially the same way as the candles in 1775 and gas in 1880. Lighting is achieved by (1) the overhead batten, (2) the footlights, (3) Standard Arc lights, (4) bunches of glow lamps behind transparencies. The chief fault is the hardness of the unnatural shadows and lack of diffusion. Nature has two methods of lighting—by parallel beams from the sun and the light from the diffused sky. Old-fashioned methods quite fail to imitate the second form of natural lighting. A complete illuminating surface resembling the sky cannot easily be obtained. Mr. Gordon Craig, who used overhead inverted arcs some years ago, attempted to meet the difficulty, but did not illuminate the actor's face. The Fortuny system, utilising reflection from colored sheets of silk, etc., is excellent both as regards delicate color-matching and shadow effect. A tightly-stretched field of colored silk, illuminated by white open arcs, returns a reflecting light which is strictly diffused and casts practically no shadow. This is the basis of the Fortuny system, and the results are very beautiful, since slow graduations of light can be used and colors mixed on the reflecting screen, just as an artist mixes the colors of his palette. Escape of reflex light is guarded against by the use of black velvet, which has a coefficient of reflection of only 2 per cent. Of special beauty is the Fortuny "firmament," which may consist of a semicircular wall painted azure blue, and stretching from the floor of the stage, well above the line of sight of the auditorium. The drawbacks to this system are that it requires a specially-designed theatre, involves much loss of light by reflection, and means high cost of maintenance.

At the Court Theatre I have tried to produce the diffusion of the Fortuny system by less complex methods, by using a series of gas-filled lamps of 1,000 candle-power at an angle of 45 degrees, colored by gelatines and rendered semi-indirect by treated glass screens. The footlights are also indirect. To imitate the Fortuny artificial sky, a large semi-circular cloth painted azure, up high, but shaded to gray in the lower parts, is used. This is likewise illuminated by tilted 1,000 candle-power gas-filled lamps, spaced to give uniform illumination. Semi-indirect movable lights are also used on the stage. There are, however, still difficulties in getting the requisite uniformity of tint and gradual changes of color in imitating sunlight and sunrise, The method, however, seems to mark a distinct advance.

The art of stage lighting is assuming an importance second to none. The great success of Rheinhardt's productions lay in his power of synthesising ability and combining the skill of the painter, the sculptor, the engineer, and the psychologist. Stage lighting may be said to be unnatural, but all art is unnatural; yet art is not of necessity crude or grotesque. To see an actor with four shadows around, as it were, in the center of a gigantic St. Andrew's cross, is highly grotesque and disturbing, whereas to see him with one unnatural deep shadow may be improbable, but yet beautiful. The whole question of lighting in relation to stage effect deserves most careful study.

* Abstract by the *Journal of the Royal Society of Arts* of paper read before the Illuminating Engineering Society by Mr. J. B. Fagan, of the Royal Court Theatre.

Wind Motors*

Their Possibilities and Limitations

By Capt. Faville C. Poulton, O.B.E., A.M.I.E.E., ETC.

THE wind motor, as a branch of engineering, is probably the oldest and also, until very recent times, the most neglected form of generating power. This is possibly due to the natural disdain one has for anything that can be had for almost nothing, and to the unreliability of the wind. Until lately it could only be used at the moment when it was blowing; but with modern and efficient systems it is now possible to conserve or accumulate this power, and so render it available in the form of energy when and where required. It is a very common thing to hear even experienced engineers say "The wind motor is not efficient." I beg to claim a good case for its consideration on "efficient grounds," if no others.

There are only three power-producers worthy of notice, namely, coal, water, and air. If we take in each case a plant of the same horsepower, and generate electricity at the same efficiency for the dynamo, we shall have the following figures: Water-power with a modern plant gives 70 per cent.; air with a modern wind motor properly installed gives 15 per cent.; coal with a modern steam-plant coal at 15,000 B.T.U. per lb., gives 13 per cent. Thus I feel that there is room for the wind motor in these days of super-economy in all appertaining to coal usage.

As this article is dealing only with wind motors I will not say anything further about either of the others, except perhaps a word here and there in comparisons.

WIND MEASUREMENTS AND METHODS OF MEASUREMENT.

The wind, at any point of the earth's surface, is constantly varying in strength and direction throughout the year. The change in direction may be momentary, or a decided change in compass direction. The former changes are due to local conditions and influences, such as surrounding objects which may exert their influences by deflecting the wind. These have to be considered by the wind motor erectors, who must choose a position as free as possible from such disturbances.

Whilst it is true that the earth's contour at any given locality has a great influence upon the prevailing winds at that place, at altitudes above the influence of the surface the prevailing direction of the winds in many places is well defined, and at certain places they have the name of "Trade Winds." In a mountainous country the wind naturally takes the direction of the valley.

A wind is not a steady moving volume of air but a series of small waves of wind of varying velocities within the large volume, just as the resultant voltage of an alternating dynamo is made up of many inter-voltages, many of which are higher than the resultant voltage.

The measurement of wind velocities is one of the important duties of the Meteorological Observatory Stations, and self-recording instruments are installed in most of these. These instruments are usually one of two types: (1) Pressure recorders; (2) the "Robinson" anemometer. The latter is the most used, and consists of four semispherical cups, hollow and fixed at the ends of four arms, made so as to be capable of rotation with a minimum of friction. The wind operates on the concave side of one and the convex side of the one on the opposite arm, causing rotation due to unbalanced pressure. The speed of rotation is calibrated, and forms a record on a drum through suitable gearing on to paper. The pressure-recording instrument responds to the rapid fluctuations of the inter-wind of a steady wind; thus these records give not a line but a series of maximum and minimum readings, just as does the oscillograph with an alternating current.

An examination of the records of the nearest observatory will tell those who propose to erect a wind motor the prevailing direction of the winds and the extremes in intensity, as well as the average velocities.

As a wind motor is capable of taking advantage of winds from any point, it is not of great moment to know the directions from which they come, except in cases when they come from one direction and are of very excessive violence, when the engineer will have to take extra precautions in designing. What interests the air motor engineer is the average velocity over a definite period, and the variation of wind velocities from day to day.

Before deciding upon the type of wind motor, or even whether it is advisable to erect one at all, the engineer should obtain access to the records of the nearest observatory, when it will be quite possible to predict with very considerable accuracy what may be obtained from a motor should it be erected within a definite district and under certain conditions of locality. Thus, *e. g.*, it may be pointed out that for one month, taken at random, the number of possible hours was 31×24=744, and the number of hours during which the wind exceeded 10 miles per hour was 507; from this it is seen that, should the motor have been set to operate full load at 10 miles per hour, there was 41 per cent. of the possible time when it could have been usefully employed for full load. There are, I can say, very few stationary steam plants that would be expected to do this, and a steam plant when not in use for short periods consumes coal or fuel, which can hardly be said of the wind motor; and, further, it would in all probability have generated from one-quarter to full power for a further 25 per cent. of the time. It has therefore been possible to have available 41 per cent. of 744 hours full load and 25 per cent. of 744 hours at, say, half load. Assuming a unit of power to be 1 h. p. at the dynamo terminals, the motor would have stored in an accumulator some (746×307)+(746÷2)×188=229,022+70,124=299,146 watts, or 2,990 Board of Trade units. The efficiency of the accumulator is slightly above 95 per cent.; but, taken at a very conservative basis of 90 per cent., there is actually available for operating, lighting, and motors, some 2,971 Board of Trade units.

With reference to average winds, these are for the United Kingdom a little in excess of 16 miles per hour for almost eight hours per day for over two-thirds days in the year. These averages are seasonal, and made up as follows: January, February, and March, 16.8 miles per hour; April, May, and June, 17.2 miles per hour; July, August, and September, 13-6 miles per hour; October, November, and December, 16.5 miles per hour. Also, it is well to note that all winds from north-west, north, north-east, and east, have an average velocity just in excess of one mile per hour of any other compass direction.

The pressure of the wind is not proportional to the velocity, for if a wind of, say, 25 miles per hour gives a pressure of 1.8 lb. per square foot, a wind of 50 miles per hour at the same point would give a pressure of 7.5 per squar foot. I say both tests taken at the "same point" advisedly, for altitude has, as I will attempt to show later, to be considered. Thus it is possible to construct a wind motor with a definite sail area that will give theoretically all the following powers with varying wind velocities at one situation and with the barometer constant:—

Horse-power.	Wind at miles per hour.
2	8
5	10.75
7	14
8	16.25
9	19
10	22

With reference to the altitude at which the wind motor is to be erected having any effect upon its efficiency, I believe I am right in saying that this point has never yet received any consideration from the designers or manufacturers, and to my mind it has a considerable bearing upon the resulting efficiency of the plant. At sea-level we have 29.5 in. of mercury, at 1,000 ft. reading 28.5: this, with (as is usually the case in the United Kingdom with high altitudes) a low atmospheric pressure due to rain, will give a further 1 to 1.5 in., bringing it for 1,000 ft. to 27.5, or 27 in. This points to a rarefied state of the atmosphere (as the aeronauts have proved.) This rarefication of the atmosphere produces on the wind motor what is the equivalent to the slip on the aeronaut's propeller. Thus a wind with a velocity of 8 miles per hour at this altitude would not produce 2 h. p. as it would at sea level, but 91 per cent. of 2 h. p. Reverting to the number of B.T.Us of electricity produced we should now have only 2,700 instead of 2,971, or a definite loss due to putting up the wrong size of motor of 270 B.T.Us, which, for one month's working, is a considerable loss, especially when efficiency has to be considered, and the extra first cost would hardly be noticed in increase of capital outlay.

THE MODERN WIND MOTOR.

The modern wind motor is absolutely unlike its ancestor, which had, as a rule, arms or sails with a diameter or sweep of up to 40 ft. The modern one has what may be termed a wheel with a number of slats set at an angle. The largest wheels are 50 ft. in diameter, but the majority are from 10 to 15 ft. in diameter; in fact, there is a tendency for the manufacturers to make 12 ft. a standard. These motors are erected upon steel towers which, according to local conditions, may be anything up to 80 ft. high.

The steel tower must be well braced and a ladder provided to give access to the platform at mill head. Water tanks are sometimes mounted some way up the tower, which renders necessary heavier construction to withstand the extra strains and stresses.

The foundations must be of concrete in which the uprights are properly embedded. No departure from this should ever be permitted without the sanction of a qualified engineer, as an overturning wind motor is a very serious catastrophe.

The steel towers are usually of light angle iron. I have seen three-legged motors, but I would strongly deprecate this practice as a false economy, for it renders overturning and buckling more liable to happen. The wheels are constructed of either galvanized iron or wood, the detals of construction of these vary in details and principles:

1. Those having moving vanes or sails.
2. Those having fixed vanes or sails.

Any tendency of the wheel to collapse is overcome by one of two methods:

1. Extending the axle and attaching, by means of a star casting, guy rods, which are fastened to the wheel at a radius from the center.
2. By having the radius of the wheel forward of the axle line.

The essential parts of a wind motor are:

1. The wheel.
2. Method of keeping it up to the wind at all times.
3. Method of transmitting the generated power to the required point.
4. Safety devices, such as self-luffing and governing.
5. Starting and stopping gear.

THE WHEEL.

This can be from 6 ft. to 50 ft. in diameter—the latter is exceptional. The sails are made of either wood or metal. When the cost of aluminum is reasonable this will be an ideal metal for sail manufacture. Metal is better than wood in so much as it can be shaped to the most advantageous curve. (This is a subject that can hardly be entered upon in this article, but I will give any information, if desired. I will only say here that this curve has a very great effect upon the efficiency of the motor at a given wind velocity at a given density.)

VEERING APPARATUS.

The majority of wind motors have a tail vane upon an extension, upon which the wind acts until it has brought the wheel fully into the wind. When it is desired to stop the motor it is brought parallel with the wheel, thus causing the wheel to come parallel to the wind. This is operated from the ground by a chain.

Unless the tail is the correct size the head of the mill will either oscillate all the time, and thus cause serious unnecessary strains on the whole structure, or it will prevent the wheel from rapidly turning to the wind.

TRANSMISSION APPARATUS.

This depends upon what kind of machinery the motor is intended to operate, for there are various types of transmission—namely, rotary, reciprocating, electric. The first two are commonly used, and the last I am now having constructed for my own use.

* From *Journal of the Royal Soc. of Arts.*

SAFETY DEVICES.

These are automatic governors to prevent the motor from destroying itself by running away in a storm, and are of the following types:

Automatic alteration of the angle of the sail to the direction of the wind, according to its velocity.

Automatic change of angle of wheel in relation to the direction of the wind.

STARTING AND STOPPING GEAR.

In the case of movable sails these are made to go parallel to the wind; in the other cases the tail is slewed round to become parallel with the wheel.

POWER OF A MODERN WINDMILL (WIND MOTOR)

If half a dozen wind motor manufacturers were examined it would be noticed that hardly two would quote the same power for the same sized motor, and if this form of prime mover is to have fair play it must have a form of rating that the ordinary purchaser will recognize. The following is my suggestion for the way in which a specification should be drawn up:

1. Horse-power required.
2. Altitude or height above sea-level.
3. Wind at miles per hour at which the mill will give horse-power in No. 1.
4. Diameter of wheel.
5. Speed regulation to within x per cent. with fluctuating wind.
6. Revolutions per minute.
7. Can be set to a maximum horse-power at a wind velocity of x miles per hour.
8. Height of tower.
9. Price.
10. Regulation, type of.
11. Braking, type of gear,
12. Throwing out gear, type of.
13. Type of drive.

With this information given, it would be possible to have a definite power for any altitude and wind velocity. In cases where a specially fine speed regulation is necessary—as, for instance, "weaving"—this can be obtained by one of two methods: (1) Cone pulleys connected by a belt; (2) weighted pulley to allow slipping belt. In the case of electric generation with the modern dynamo it is possible for the dynamo to regulate itself to an extent that renders special regulating gear unnecessary, for the voltage is maintained constant at any load from zero to full load.

With reference to the advisability of installing wind motors of large diameters, I am of the opinion that it is far more efficient to have many mills of reasonable size than a few very large, for the following reasons: (a) Excessive weight of wheel necessary to withstand the stresses; (b) large starting torque; (c) large and heavy towers necessary; (d) great expense from causes (a) and (c). In fact, for equal safety factors the weight of the wheels should be proportional to the cubes of their diameters. It would require, however, four mills of 6 ft. diameter to equal the power of one mill of 12 ft. diameter but this tower would require to be not less than twice the weight of the four smaller towers combined. To sum up, it would be more economical and efficient to have smaller units coupled together for the reasons: (a) lower starting torque; (b) being separated they would get more wind; (c) higher all-round efficiency and easier regulation; (d) risk of a complete breakdown reduced to a negligible minimum. It has frequently been stated that a battery of connected wind motors is not satisfactory; but with modern methods this is not only satisfactory but highly efficient.

Taking the average wind for the United Kingdom for 1918, I find that out of a possible 8,760 hours the wind blows at:

8 miles per hour and over for 7,708 hours, or 88 per cent. of possible hours.

10 miles per hour and over for 6,854 hours, or 71 per cent. of possible hours.

12 miles per hour and over for 5,256 hours, or 60 per cent. of possible hours.

15 miles per hour and over for 3,941 hours, or 45 per cent. of possible hours.

20 miles per hour and over for 2,452 hours, or 28 per cent. of possible hours.

25 miles per hour and over for 1,576 hours, or 18 per cent. of possible hours.

30 miles per hour and over for 700 hours, or 8 per cent. of possible hours.

Now, taking the average working week at forty-eight hours and fifty weeks per year, the most economical wind for this would appear to be twenty miles per hour (subject to locality).

The next consideration is, when is the work required to be done? If it is possible to do the work when the wind blows, as used to be the case in flour-milling, the problem is simple, as no accumulation of power is necessary against the times when the wind is not blowing; but as only very few operations can be carried out under these conditions, it is necessary to have some form of accumulator to store the power so that it can be used at convenient hours. This accumulation can be done by several ways, as, for instance: Electrical accumulators; hydraulic accumulators. Each of the above has advantages over the other for certain duties. Thus for a small engineering works the electrical is advisable if machine drive is required, but when hydraulic machines are required the hydraulic accumulator is more suitable.

As to the question of costs, assuming the wind motor to deliver 2 h.p. at sea-level for a wind velocity of twenty miles per hour, the size of wheel would be 16 ft. in diameter, and the cost: Wind motor, £90; accumulators, £80; dynamo, etc., £20; total, £190—say, £200. Interest at 5 per cent., £10; depreciation at 7 per cent., £14; upkeep, etc., £5—total, £29. Thus there is available 2 h.p. for 2,400 hours for 29£, which works out at 0.8*d*. per horse-power hour, and there is no power except water that can be generated for this figure in small units. Should it be desired to have a large unit, say, a mill or lighting plant, it is not advisable to have excessively large wind motors as has already been pointed out, but to utilize a standard size and have these arranged to work together in an efficient manner on to a common shaft.

Among the practical applications to which wind motors can be put, are:

1. Corn grinding.
2. Pumping.
3. General farm machinery—
   - (a) Power-driven wood saw.
   - (b) Chaff cutter.
   - (c) Swede cutter.
   - (d) Corn crusher.
   - (e) Hay press.
   - (f) Potato-washing machine.
   - (g) Butter-making machine.
   - (h) Cheese-making machine, etc.
4. Workshops—
   - (a) Engineering: lathes, grinders, millers, etc.
   - (b) Joiners: lathes, saws, etc.
   - (c) Smiths, blowers for forges and power hammers, etc.
   - (d) Bootmakers and repairers' machines.
   - (e) Woollens (knitting machines).
   - (f) Sewing machines.
   - (g) Small weaving machines and looms.
   - (h) Village lighting.
5. Generation of electricity for light and power.

Each of the above requires individual consideration to obtain the best results. To the writer's knowledge there are many plants operating with every satisfaction on Nos. 2, 3, 4, and 5.

How Could a Rotating Body Such as the Sun Become a Magnet?*

By Sir Joseph Larmor.

The obvious solution by convection of an electric charge, or of electric polarisation is excluded; because electric fields in and near the body would be involved, which would be too enormous. Direct magnetisation is also ruled out by the high temperature, notwithstanding the high density. But several feasible possibilities seem to be open.

(1) In the case of the sun, surface phenomena point to the existence of a residual internal circulation mainly in meridian planes. Such internal motion induces an electric field acting on the moving matter: and if any conducting path around the solar axis happens to be open, an electric current will flow round it, which may in turn increase the inducing magnetic field. In this way it is possible for the internal cyclic motion to act after the manner of the cycle of a self-exciting dynamo, and maintain a permanent magnetic field from insignificant beginnings, at the expense of some of the energy of the internal circulation. Again, if a sunspot is regarded as a superficial source or sink of radial flow of strongly ionised material, with the familiar vertical features, its strong magnetic field would, on these lines, be a natural accompaniment; and if it were an inflow at one level compensated by outflow at another level, the flatness and vertical restriction of its magnetic field would be intelligible.

(2) Theories have been advanced which depend on a hypothesis that the force of gravitation or centrifugal force can excite electric polarisation, which, by its rotation, produces a magnetic field. But, in order to obtain sensible magnetic effect, there would be a very intense internal electric field such as no kind of matter could sustain. That, however, is actually got rid of by a masking distribution of electric charge, which would accumulate on the surface, and in part in the interior where the polarisation is not uniform. The circumstance that the two compensating fields are each enormous is not an objection; for it is recognised, and is illustrated by radioactive phenomena, that molecular electric fields are, in fact, enormous. But though the electric masking would be complete, the two distributions would not compensate each other as regards the magnetic effects of rotational convection: and there would be an outstanding magnetic field comparable with that of either distribution taken separately. Only rotation would count in this way; as the effect of the actual translation, along with the solar system, is masked by relativity.

(3) A crystal possesses permanent intrinsic electric polarisation because its polar molecules are orientated: and if this natural orientation is pronounced, the polarisation must be nearly complete, so that if the crystal were of the size of the earth it would produce an enormous electric field. But, great or small, this field will become annulled by masking electric charge as above. The explanation of pyro-electric phenomena by Lord Kelvin was that change of temperature alters the polarisation, while the masking charge has not had opportunity to adapt itself: and piezo-electric phenomena might have been anticipated on the same lines. Thus, as there is not complete compensation magnetically, an electrically neutralized crystalline body moving with high speed of rotation through the æther would be expected to produce a magnetic field: and a planet whose materials have crystallised out in some rough relation to the direction of gravity, or of its rotation, would possess a magnetic field. But relativity forbids that a crystalline body translated without rotation at astronomical speeds should exhibit any magnetic field relative to the moving system.

The very extraordinary feature of the earth's magnetic field is its great and rapid changes, comparable with its whole amount. Yet the almost absolute fixity of length of the astronomical day shows extreme stability of the earth as regards its material structure. This consideration would seem to exclude entirely theories of terrestrial magnetism of the type of (2) and (3). But the type (1), which appears to be reasonable for the case of the sun, would account for magnetic change, sudden or gradual, on the earth merely by change of internal conducting channels: though, on the other hand, it would require fluidity and residual circulation in deepseated regions. In any case, in a celestial body residual circulation would be extremely permanent, as the large size would make effects of ordinary viscosity nearly neglible.

* From *English Mechanic and World of Science*.

Concrete Mine Timbers

Hollow concrete posts for use as mine timbers have been devised by a Belgian engineer. The new system, which is designed to permit of settlement if the support is overburdened, consists essentially of a hollow reinforced-concrete column, filled with sand or some other slightly compressible material through which the load is transmitted. In one form the timber is in three parts. An arch for the roof is of pre-cast concrete and is provided with a tenon which fits into an opening in a hollow post. The bottom of the post fits over a tenon on a base block. Spiral reinforcement is provided for the post, which has to resist, at the beginning of loading, the radial compression of the sand which fills the hollow and which is compressed under load on the frame. If the roof settles, the sand will compress a certain amount, and if this amount is beyond the length of the tenon the post commences to take compression.

In another form the roof is supported by a direct wooden post penetrating into the top of the opening in the hollow concrete column. The movement, in the event of a settlement of the roof, is taken care of by the ejection of the sand through an opening at the bottom.—Abstracted from *Genie Civil*, by the *Technical Review*.

When rough hewing a block for a piece of statuary the contours are determined by a simple gage

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Tools operated by compressed air now take the place of mallet and chisel

Mechanical Aids for the Sculptor

Modern Machine Tools for Carving and Cutting Marble

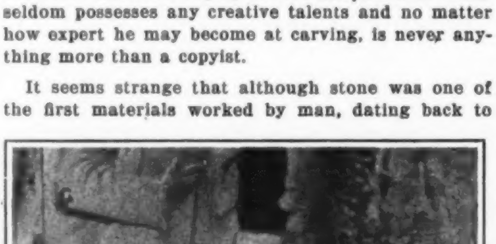
By Gordon Van der Veer

It was Michael Angelo, we believe, who said that the art of sculpture consisted merely in cutting away from a block of stone the parts that you did not want, and he was wont to illustrate the definition by attacking a block of marble with such vigor that big pieces of stone flew in all directions from under his chisel and hammer. Modern sculpture is hardly effected in that way. The sculptor of today seldom puts his hand to the stone. In fact, there are many sculptors who do not know how to handle the chisel, confining their manual efforts to clay and wax. In some cases even the model is made by assistants from sketches furnished by the sculptor. Fortunately such instances are rare, but at all events Michael Angelo's definition hardly applies to present day practice.

Now-a-days a preliminary sketch is first carefully modeled in clay or wax. This is made on a small scale and it is here that the sculptor exercises his creative art. Then if the statue is to be made life-sized or colossal, an "armature" is constructed, which consists of a skeleton of iron bars roughly conforming to the pose of the figure. This is mounted on a revolving platform, so that all parts may be turned to the light, facilitating the work of the sculptor. On the armature modelling clay is applied and the miniature model is faithfully reproduced in full scale. The next step is to apply plaster of Paris over the clay to form piece molds. The plaster pieces are then removed and reassembled to form a hollow mold. A hollow plaster cast is made within the mold by pouring in a thin mixture of plaster and washin it around until it forms a coating on the mold. The work is completed by removing the piece mold and, if the mold has been carefully fitted together ,the resulting cast will scarcely show any lines where the pieces were joined. The sculptor may then put the finishing touches on the plaster model. Thereafter the work is merely one of copying the plaster model in marble, and this is left in the hands of assistants.

A "pointing machine" is used for roughing out the work. The plaster model is set on a block and all the salient points are marked. The marble is set on an adjacent block and by means of the pointing machine the same marks are transferred to it. The pointing machine consists of a series of levers that operate somewhat on the principle of a pantagraph. The marble is bored at the points indicated by the pointing lever at such an angle and to such a depth as to bring a "needle" at the other end of the lever directly on the mark on the model. In this way the marble is bored with a series of holes indicating where and to what depth it is to be chiseled away. A man known as a *scarpellino* then cuts away the stone down to the bottom of the holes. This does not require a great measure of skill and is entrusted to comparatively inexperienced hands. From here on, however, the work calls for an expert, and can be done only by a highly skilled *scarpellino*. The difference between the old masters and the modern sculptor is that the former combined the creative talents with the skill of the *scarpellino*, while the latter seldom possesses the ability of actually transferring his creation to the stone. On the other hand the highly skilled *scarpellino* of today seldom possesses any creative talents and no matter how expert he may become at carving, is never anything more than a copyist.

It seems strange that although stone was one of the first materials worked by man, dating back to



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A marble carver verifying points on a figure by means of special dividers

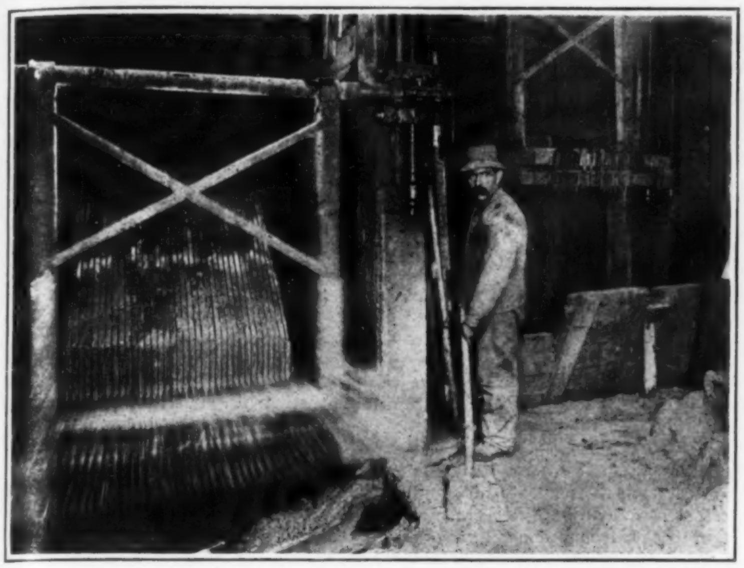
the prehistoric ages, it was one of the last of materials to yield to machine tools. Until within recent years only the chisel and hammer were used to shape stone, even for architectural and commercial purposes. The earliest machines for sawing stone consisted of toothless iron saws which wore their way through the stone with the aid of sharp sand and water. A later development was an endless band of steel wire. This is run at high speed around a couple of pulleys. Stone pressed against the wire is slowly worn away, the cutting action being expedited by the use of suitable abrasives. Diamond saws have also been used to considerable extent, the saws consisting of steel disks on the periphery of which black diamonds are embedded.

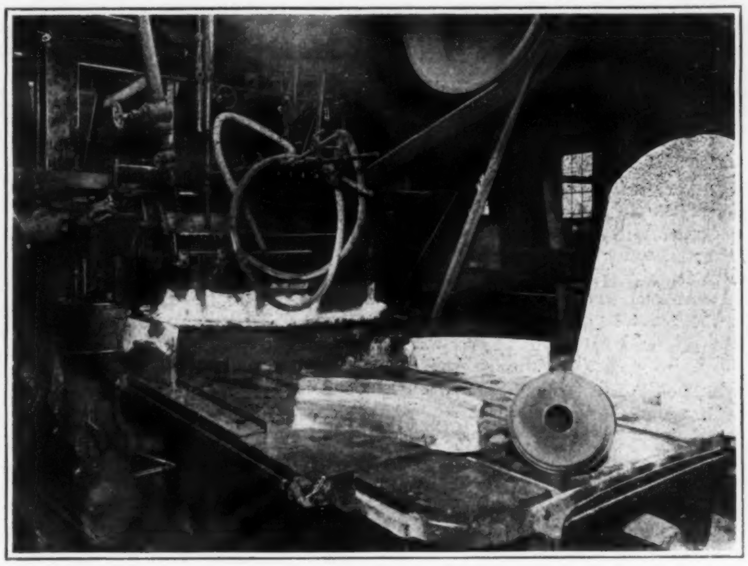
With the advent of carborundum, however, the machining of stone has developed by leaps and bounds. We now have machines for sawing, planing and turning stone, and to these machines the hardest of materials must yield. The stone is cut almost as readily as soft steel in the machine shop. The carborundum saw consists of a steel wheel with carborundum bonded to its periphery. The saws are often mounted in gangs, so as to cut a number of slabs of stone at a single run. Ornamental columns, newel posts and the like are first roughly shaped with a saw. The block is mounted in the lathe and slowly turned against a saw, which cuts a series of parallel kerfs to the requisite depth. Then the stone between the saw cuts is broken away and the roughed out block is pressed against a revolving carborundum drum molded to give the stone its finished shape. The final process is to polish the stone with another finer grade of carborundum drum.

In art work we can hardly expect to find machines used extensively, but the work of the *scarpellino* is now considerably expedited by the use of pneumatic tools. Chisels driven by compressed air, on the same principle as the pneumatic rivetter, eat away the stone very rapidly, and the cutting can be controlled even more readily than with the hammer. Machines are also used for forming pedestals and for cutting the curved moldings that are used to frame carved panels. A photograph of such a machine is reproduced on the opposite page. Despite the sculptors' aversion to anything mechanical, machines are actually forcing their way into the realms of art, and there is no reason why they should not, particularly as the actual carving of stone today is really a process of copying. Surely it is permissible to reduce the drudgery of this work with mechanical aids. However, the final touches express the skill of the expert scarpellino and for this work he usually prefers to stick to the old time chisel and hammer.

The Largest Clamshell Bucket.

The huge clamshell bucket used to dredge the approaches to the drydock at Sparrows Point, Md., is claimed to be the largest in the world. The bucket alone weighs 40,000 lbs. and will lift 30 cubic yards of mud at a bite. The capacity of the bucket has been increased by using side boards above the jaws to hold in the extra material which rises above the top. Specially dump scows had to be designed for use with this dredge to take the shock of the heavy loads dumped upon them. Ordinary scows would soon have been wrecked in such heavy service.





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Large blocks of marble are sawed into slabs of any desired thickness by this machine

This machine cuts the curved moldings that surround curved panels

Submarine Acoustics.

By F. Lloyd Hopwood.

The war has been responsible for great developments in many branches of science. As a consequence of the submarine menace, close attention has been given to the subject of marine physics, with the result that notable advances have been made in several directions, especially in that of submarine acoustics. Much of what has been accomplished is still regarded as confidential information, but some interesting disclosures have recently been made by Prof. W. H. Bragg in the Tyndall lectures delivered before the Royal Institution, and in a lecture at the British Science Guild's Exhibition at Westminster.

The singular property which distinguishes a submarine from other ships is its capacity of rendering itself invisible when pursued or when seeking and attacking its prey. Robbed of this power, it is an extremely vulnerable craft, and falls a ready victim to more heavily armed and amored surface ships when once its presence has been detected and its position located.

The acoustic method of detecting a submerged submarine moving in the open sea was found to be far more sensitive and to give a much longer range than all other methods. Instruments used for this purpose are called hydrophones. Many varieties of hydrophone have been evolved and perfected, but by far the largest class consist essentially of a microphone attached to a diaphragm which forms one wall of a watertight cavity. The microphone is connected through a suitable electrical circuit to ordinary telephone receivers, the complete installation resembling a unit of an ordinary land telephone system. In use the hydrophone is suspended from the bulwarks of a stationary ship, or mounted in tanks attached to the hull, or trailed behind in a suitable "fish" body in the case of a moving ship. The range of a hydrophone depends upon the size and speed of the source of sound, the depth and state of the sea, the presence of other sources of sound, etc., and may vary from a few hundred yards to several miles.

The difficulty of ascertaining the *direction* of a source of sound has been overcome in a number of ways. One type of directional hydrophone is shown in Fig. 1. In this instrument *both* sides of the sensitive receiving diaphragm are in contact with the sea, the microphone being incased in a small capsule at the center of the diaphragm. If used in this form the instrument is deaf to sounds in its equatorial plane, but can hear sounds coming from other directions. It is, in fact, the reciprocal of the hypothetical "double source" of Helmholtz. The polar curve, showing the dependence of its response upon its orientation with respect to the source, is given in Fig. 2.

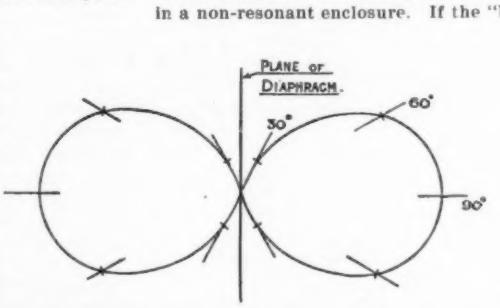

Fig. 2 Direction-sensitiveness polar curve of a bi-directional hydrophone

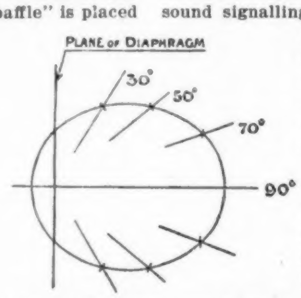

Fig. 3. Direction sensitiveness polar curve of a unidirectional hydrophone

It is obvious that the ambiguity involved in the *bi-directional* qualities of such an instrument would seriously diminish its efficiency in actual practice, and accordingly a modification was introduced to eliminate this defect. This consisted in the attachment to the hydrophone carcass, at some distance away from the sensitive diaphragm ,of a bias plate, or "baffle," as it is now called. This can be seen in the side view of Fig. 1. When correctly adjusted in position, the "baffle" modifies the polar curve of Fig. 2, so that it takes the form shown in Fig. 3, and, as can be readily seen, renders the hydrophone *uni-directional.*

The construction and properties of "baffles" are

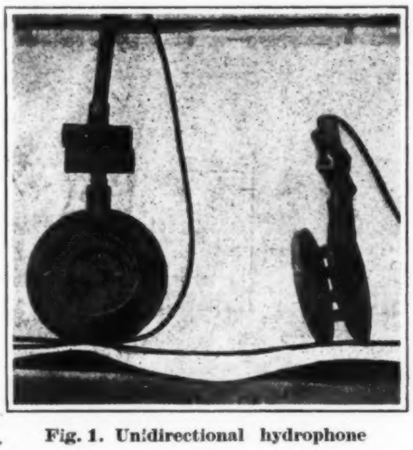

Fig. 1. Unidirectional hydrophone

very interesting, and have been the subject of prolonged investigation. The mathematical theory of their action has not been worked out fully, as it is difficult to specify all boundary conditions. Moreover, the phenomena are of the diffraction type, in which the obstacle is small compared with the wavelengths of the incident disturbances. A fairly complete empirical knowledge of their properties has, however, been obtained. The essential feature of their construction is the inclusion of a film of gas in a non-resonant enclosure. If the "baffle" is placed too close to the receiving diaphragm, the hydrophone becomes non-directional, a limiting case being that in which one side of the diaphragm is completely enclosed, and, therefore, "over-baffled."

In his lectures Prof. Bragg also briefly described two other methods by which the direction of an under-water source of sound could be ascertained by making use of a number of hydrophones which do not themselves possess intrinsic directional properties. In the first of these use is made of the binaural principle. Two hydrophones are mounted on a rotating arm at a distance apart of from six to eight feet, one hydrophone being connected to the right ear-piece of the observer's telephone, and the other to his left ear-piece. If now the wave-front of the oncoming sound strikes the right-hand hydrophone first, the sound appears to come from the observer's right. On rotating the arm the hydrophone on the left side can be advanced so that the sound appears to come from the left. By rotating the device until the sound appears to come from ahead or astern, the observer is enabled to detect the direction of the source, a simple rule enabling him to resolve any fore-and-aft ambiguity. Instead of rotating the arm carrying the hydrophones, the angle which the wave-front makes with it can be found by compensating for the difference of path in water by introducing an equivalent length of air column between one or other of the observer's ear-pieces and his ear. In this case three hydrophones have to be used in pairs in order to obtain the direction of the source uniquely, the bearings being read off from the calibrated scale of the "compensator."

The second method consists in making use of the phase relationships between a number of hydrophones distributed at regular intervals in a straight line. It is obvious that in this case sound-waves from a distant source arrive in phase only when it is situated on the beam of the line of hydrophones. By making use of a multiple "compensator" the phases can be corrected for all directions, and the bearing of the source read off from the "compensator" when the observer has determined the setting for maximum intensity.

One gratifying feature of the work on submarine acoustics done during the war is the possibility which it provides of rendering navigation more safe in times of peace. Used in conjunction with suitable sound signalling apparatus fitted to vessels, and submarine bells moored near dangerous shoals and rocks, the improved hydrophones developed for war service should greatly reduce the dangers of collisions and shipwreck, due to fog, etc.

Already hydrographic surveys of the North Sea are being carried out in which the position of danger spots are located for charting purposes by exploding depth charges and recording the resulting disturbances at a number of hydrophones connected to land stations. This method of submarine sound-ranging is by far the most accurate method of locating such spots, and also provides a means of enabling a ship at sea to obtain its correct bearings. By dropping a bomb hundreds of miles at sea, a ship can in a few minutes communicate its position to the nearest shore station and receive this information itself back again by wireless.—From *Nature* (London).

Electrical Conditions of the Earth and Atmosphere

Their Influence Upon Animate Nature

By A. E. Baines

Although the subject of electrical conditions of the earth and atmosphere and their influence upon animate nature is one of widespread interest and importance, I have not been able to find any literature dealing with it and am therefore encouraged to place such knowledge as I possess at the disposal of the general public.

A few months ago I pointed out to the eminent English scientist, Dr. Russell, that in his admirable work, Soil Conditions and Plant Growth (Longmans), he had omitted all consideration of electrical phenomena. In his replay he said, "We have not gone into this question of electrical conditions, because I am not yet satisfied as to the evidence."

Evidence there is, in plenty. That it has not been published is a matter for regret. Now that attention is being directed to electro-culture it is very necessary to have some understanding of the part played by Nature, and of her methods before we seek to improve upon them. Experimentation without a starting point, a definitely ascertained basis of fact very seldom results in success, and in this case the basis is not wanting. .

In countries free from frequent magnetic and seismic disturbances and in normal conditions of weather the earth is always the negative and the air the positive terminal of Nature's electrical system.

The air is not only charged by some source or sources of energy in the Solar System, or at all events above the air limit, but is from time to time the carrier of currents of high potential from clouds which acquire a static charge in the course of their movements.

The earth, therefore, is perpetually in process of electrification, and its receptivity is dependent for its degree upon the conductivity of its upper stratum. Dry soil is a non-conductor, or at all events a very bad conductor of electricity, and uniformity of electrification could only be possible if the resistance of the upper stratum of the soil were everywhere the same. To that question we will, however, return later.

Everything growing in the soil is charged—electrified—by the earth through the roots, rhizomes, stems and venation; the negative terminals of the tree, shrub or plant. The aerolae, or those parts of the leaves between the venation, take their charge from the positive air, so that there is in every case an ordinary electrical current, i.e., air to earth and back again through the plant to air.

That, however, does not exhaust the phenomena we are about to pass in review. Earth-currents proper are set up both occasionally and frequently in different parts of the world by chemical reactions taking place in the earth itself and, furthermore, modernity has, in some of the large towns, introduced a new factor in a multiplicity of electrical railways, tubes and tramway systems; and this factor must be considered in relation to the accepted theory that, as compared with all other electrical tensions, the earth is "zero."

In certain localities and in abnormal weather in other localities, the earth may become very highly charged. The terms "positive" and "negative" are misnomers. Let us substitute for them the words "plus" and "minus."

The air, the upper stratum and, hypothetically, stretching upwards to infinity, is always "plus," the earth, usually, "minus."

Between a charged cloud and the comparatively uncharged earth there is an air-space—the spark-gap, as it were—and unless the tension of the cloud is sufficiently high to bridge it no discharge can take place. Over a flat surface of ground or above a surface either very dry or composed of some dielectric material, such as shale or marl, the the cloud would pass without discharging, but when by reason of contour the distance between earth and cloud was lessened to one that the tension of the cloud could overcome, or, alternatively, tension being enough, a point was reached where the soil favored conduction, a transfer of potential from the plus cloud to the minus earth would at once take place, in exactly the same manner that a spark is obtained from a Leyden jar or induction coil when the conducting knobs or points are approached to each other.

Ordinarily such a discharge would, when received, be diffused over a wide area of ground, but let us suppose that it is directed to a pocket of earth in a basin of shale, or clay, or marl, or stone so that it could not be readily dissipated and that another cloud which had already discharged itself passed over the position within a distance over which the spark gap could be bridged. The result would be a discharge from earth to cloud, because the earth would have become the plus and the cloud the minus quantity.

The Natural electromotive force of man—so far as it can be expressed in electrical terms—is about five millivolts, or five thousandths of a volt. He is almost as receptive of direct or induced charge as the earth is, and any sudden and violent interference with that electromotive force by an external source or vehicle of energy would temporarily have a mischievous effect upon his nervous system.

That is a danger to which we are not ordinarily exposed, but to a modified extent we may regard the electrical phenomena consequent upon the operation of an electric railway as analagous to that we have been discussing, leading for electrified clouds the effect upon the air of alteration or load, while the iron-clad tubes, with their far from perfect insulation, must be responsible for artificial earth-currents of considerable intensity.

Similarly, in tramway lines where direct current is employed the overhead system is likely to affect the air locally, and the conduit system to charge the earth, although the range of inductive interference is not nearly so great as in the case of electrified railways and tubes.

Quite apart from thunderstorms and kindred disturbances, the earth is electrically "patchy"; the potential and direction of current varying in different parts of the world. The mean of a series of tests taken at the instance of one of the great cable companies gave eight volts as the E.M.F. of the earth-current traversing short cables, but I am credibly informed that at Port Arthur it has sometimes risen to 500 volts.

Darwin found the neighborhood of the Rio Plata to be peculiarly subject to electrical phenomena, and on the East African coast the earth-current has remained at forty volts for many weeks in succession.

Flammarion attributed the Aurora Borealis to the striking of a balance, silent and invisible, between the two opposing tensions of the atmosphere and earth; the apparition of the Aurora Borealis in Sweden or Norway being accompanied by electric currents moving through the earth to a distance sufficiently great to deflect the magnetic needle in the Paris Observatory.

The same writer expressed the opinion that the electricity which pervades the earth is identical with that which moves in the heights of the enveloping atmosphere, and that whether it is positive or negative its essential unity remains the same, these qualities serving only to indicate a point, more or less in common, between the different charges. The heights of the atmosphere are more powerfully electrified than the surface of the globe, and the degree of electricity increases in the atmosphere with the distance from the earth.

That indeed must be so, in conformity with Ohms law, i.e., $C = \frac{E}{R}$ if we assume, as we must, I think, assume the source of electrification of the atmosphere to be above the air limit, because resistance attenuates electrical energy in proportion to the distance traversed by it, i.e., through the enveloping atmosphere; the equation $C = \frac{E}{R}$ meaning that the current at any point is equal to the initial electromotive force divided by the total resistance in its path to that point.

That earth currents have at times an origin which is in part thermal seems not unlikely. Earthquakes are of common occurrence in the tropics and elsewhere. Dutton records an instance of an earthquake at the Yaqui river which disturbed the needle of the magnetograph at Los Angeles, a distance of more than six hundred miles, and it is possible that forces which in themselves are insufficient to cause even a slight convulsion of Nature may be responsible for the creation of high potential at one point, whence it is distributed to another point or points of lower potential; the precise path being governed by electrolytes in the earth, or, in other words, by the same law which directs the course of lightning through the atmosphere.

In speaking of earthquakes we must, of course differentiate between those which are caused by subsidences and those of volcanic origin. Volcanoes are not confined to any one part of the world, but are to be found, so far as latitude is concerned, pretty nearly everywhere; in the Arctic Ocean, in the volcanic island of Jan Mayen, between Iceland and Spitsbergen; there are Mount Erebus and Mount Terror in the Antarctic, besides very numerous volcanoes in the Atlantic, Pacific, and Indian Oceans, and their shores, in both the temperate and torrid zones. In all they are said to number, in a state of activity, some three hundred.

But, as Houston writes, "There are a much greater number of extinct (?) volcanoes, volcanoes which may at any time again become active."

The difficulty we are faced with is contained in the last paragraph . Were it not for the uncertain number and condition of extinct volcanoes, or rather of volcanoes which have ceased for the time being to give any manifestation of activity, we might consider earth-currents in their possible relation to areas liable to thermal disturbances with a view to determining whether connection between them is suggested by their coincidence.

One fact stands out prominently: thunderstorms diminish in frequency towards the poles, and if they are a factor in governing the occurrence and strength of earth-currents one would expect to find a minimum of disturbance towards the poles. That does not, however, appear to be the case, as currents of very high tension are met with in the far north.

As regards plant-life, the electrical condition most to be desired is soil conductivity. If the soil is not moist to the root-depth, or, alternatitvely, if it does not contain electrolytes other than water, the plant is deprived of its supply of current and must suffer injury.

If, however, about one per cent. of ferro sulphate, or another suitable electrolyte, is mixed with the soil or the ground is well watered with that mineral in solution, a great deal of the water ordinarily required may be dispensed with; the ferro sulphate taking its place as the electrolyte.

I have potted plants in baked soil with which a solution of one per cent. of the iron salt has been mixed—and then expelled—and have kept them alive in a warm greenhouse, exposed to the sun's rays, for three months without water. They did not grow, because there was no moisture for the formation of protoplasm—but they lived when the soil in the pot was electrified by means of a continuous current of low electromotive force; not when this was omitted.

Normally the moist earth in the pot is receptive of charge from the positive air and although this involves reversal of polarity on the part of the plant it manages to thrive. With dry soil, however, there is total absence of electrification; the plant becomes moribund and eventually dies.

Not only is it necessary that the soil should be conductive, but we have to take into account the factor of its resistance because this would govern the quantity of current reaching the plant-roots. If every part of the earth were of exactly the same resistance all things growing in it wou. l be uniformly electrified, but we may be quite sure that electrolytes are neither equally distributed throughout the soil, nor of uniform resistance, so that electrification cannot be everywhere the same.

When a "fault," such as a pocket of earth in a basin of dielectric material, occurs the area of the pocket is just as dependent upon air charge as the soil in a pot would be and in dry weather, with a non-conducting upper stratum it would become electrically inert. Remedial measures or attempted

remedial measures now employed take the form of breaking up the underlying dielectric, but this is only practicable when the material in question is not far from the surface.

A more simple way out of the difficulty would be to drive a metal rod or tube through the dielectric and enable the earth-current to pass through or by it from below.

Theoretically it is desirable to test soils for current and where there appears to be a deficiency to arrange for a constant supply, at a voltage not materially higher than that which normally obtains.

Furthermore we have the important matter of temperature in its relation to electrical conditions of the soil. In warm, damp weather conductivity is at its maximum. Cold increases resistance—especially of liquid conductors—and lowers the quantity of current supply. There is in fact not only diminished supply to the roots, but in very cold seasons what one might term protoplasmic paralysis, a condition which in the case of perennials merely inhibits growth, but which is generally fatal to species of the tender or half-hardy order.

When vegetable life is said to be "resting" during the late autumn and winter months it is (in my opinion) probably due to lowered electrification.

Man is liable to be affected in much the same way and we may be sure that lowered vitality not only predisposes to disease, but operates against its cure.

In the polar regions larger temperature ranges can be endured in the winter, when the air is dry. In severe cold the vitality of the body is lowered and the ability to bear hardships decreased. But here, again, the body is acted upon directly by cold. The resistance of the natural (semi-liquid) conductors is increased, the blood circulates more slowly, the surface blood-vessels contract, and only an added skin-resistance, by helping to conserve energy, and, it may be, greater purity of air stimulating generation of nerve-force, prevent the heart and lungs from becoming dangerously affected. Esquimos are protected from the cold by their fatty tissues, which give them high absolute insulation; and those frequenters of icy seas, the whales, are similarly equipped.

Any abnormal skin condition, no matter how produced, must, in my view, interfere to a greater or lesser extent with metabolism. If the skin is dry its insulating properties are at their maximum. Extreme heat combined with moisture would have the opposite effect and would at the same time lower the resistance of the nerve-substance, so that an increased quantity of current, and a path of greater facility for that current to escape to air, would be the result; bringing about a temporary loss of vitality.

The same remarks apply to exposure for long periods to damp air, except that the nerves would not be directly interfered with.

What I wish to labor is this: the human organism is provided—as an apple is provided—with a skin, or rind, the resistance of which is adjusted by Nature for the conservation of his energy, and so long as normal conditions prevail that resistance is exactly right. If the skin is wet its resistance is subnormal—if it is too dry the nervous system is liable to become neuro-electrically congested.

In this connection I am glad to find that at least one physiologist of eminence—Dr. Leonard Hill—is in agreement with me, although our interpretation of observed phenomena may not be the same. He has produced maps showing that the energetic races of the world inhabit just those regions where atmospheric coolness and drying are most potent.

Many are familiar with the unpleasant symptoms attendant upon an abuse of sea bathing. They are, of course, due to the failure, during immersion, of the resistance of the skin and it is for this reason that long-distance swimmers anoint themselves with grease. Could they insulate the mouth and eyes in the same way they would, no doubt, be able to remain in the water for longer periods.

That the atmosphere is electro-magnetically active has been postulated by Clerk Maxwell and others, and we have it upon their authority, as well as upon that of Sir Oliver Lodge, that light is an electromagnetic disturbance of the ether. Optics is a branch of electricity, and we can conceive the evolution of a potential of increasing intensity as progress is made from the red to the violet end of the spectrum. Plant growth, as shown by experiment, is at its best in a red light and the rays of long wave-length, red and infra-red, are the only ones which Nature permits to penetrate the human body. My readers will also be aware of the injurious effect of actinic light and particularly of sunlight, upon cuttings and germinating seeds and have seen the necessity of protecting them from what is really a form of energy too violent for their constitution.

Hypothetically the electrification of the atmosphere should be higher in dry than in wet weather by reason of there not being a path of low resistance to earth; but a long series of tests carried out by me last year negative this conclusion.

On perfectly dry, warm days, with bright sunshine, the average deflection of an unshunted and very sensitive galvanometer ranged from 5 millimetres in the early morning to 2.5 millimetres at night.

When it was wet—more especially with a steady, dazzling downpour, the deflections rose to 150 and not infrequently to 180 millimetres. Moreover, the initial throw disclosed a static charge, the tension of which was governed by that of the cloud or clouds discharging the rain.

Now if a vegetable or a fruit, such as an onion or an apple, be earthed *in vacuo* and its electrical charge exhausted, it ceases for the time being to yield a galvanometric deflection. Afterwards, if exposed to the air the period necessary for the restoration of its former electrical activity is dependent upon quality of the light to which it is subjected. In a dull diffused light recovery is very prolonged, but in bright sunlight half an hour is sufficient.

But—and there is a perplexing feature—the form of energy exhibited by sunlight cannot be demonstrated galvanometrically, unless it is transformed into heat, and then it is no longer a manifestation of sun-energy, but of another force which it has assisted to bring into operation.

Concerning Age.

At what time does age begin? Hippocrates puts the period at the beginning of the seventieth year, while according to Vario, the Roman citizen was retired from all public offices at sixty (Senes depontani). In Solon's elegy upon the hebdomads of human life the greatest development of bodily strength was attributed to the twentieth year. Aristotle placed the zenith of life at from thirty to thirty-five, ordinarily, but declared that it continued to the forty-ninth year in men engaged in intellectual pursuits, saying that previous to and after this stage of life there existed a "too much" and "too little," hyperbole and ellipsis, expectation and experience. This subject, of such universal and poignant interest, of the coming of age, of its phenomena and of possible means of delaying its appearance, was made the subject of an interesting discourse pronounced by a German scientist, Friedrich von Mueller, at a celebration of the founding of the University of Munich, in June, 1915, a report of which we find in *Die Naturwissenschaften*, part of which we quote as follows:

"Even with regard to the body alone all efforts to discover the boundary line of the beginning of age have remained without success. The various organs and functions undergo alteration at very various times and Friedmann is right when he says that the involution of evolution is so closely connected with its completion that decay has already begun in the period of youth. Thus the lymphatic system, the tonsils, the lymphatic gland and the thymus began to suffer atrophy as soon as the development of the sexual organs is complete. The uterus and the secondary sex characters undergo atrophy when the true ovaries have begun their activity.

"Characteristic signs of age are the eyesight of old persons, the decline of the memory and of the muscular powers and the stiffness of the limbs: *rigor signum senectutis* (stiffness is a sign of age). Athletes display no remarkable feats of strength after thirty-five years of age and reach the maximum of their muscular power before the thirtieth year. Among the workmen of the English cutlery and button industries the amount of work done, as compared with that of younger men, sinks to 80 per cent between the ages of forty and forty-five, to 60 per cent at the fifty-fifth year, and to 40 per cent at the age of sixty-five.

"The eyesight begins to exhibit a change at about fifty; however, the elasticity of the lens begins to decrease after the first decade of life and usually sinks to zero at about the age of seventy-five.

"The power of observation is so great in youth that 70 per cent of all intellectual acquirements are obtained during this period, while difficulties appear after the age of thirty. Since with increasing age the power of receiving new impressions and making them effective diminishes, there is a narrowing in the boundaries of the intellectual domain; an aged person is often indifferent or even hostile to modern ideas, he has a decreased comprehension of the interests of youth and of its right to manage matters differently from the way they were done in the time of his own youth. With the increasing poverty of recent intellectual gains the firmly fixed memories of his youth gain in intensity and there is some justice in the view that the beginning of age dates from the time when the intellectual vision ceases to be directed towards the future and is bent upon the past. Earnest and serious thoughts engage the mind more and more; he who was formerly a seeker for truth becomes a doubter, the freethinker becomes a believer, the revolutionary a conservative. The greater the decrease in the power of adaptation the greater the power of habit becomes. The emotional life shrinks more and more to the narrow circle of the personal ego and its most immediate needs . . . the increasing susceptibility to fatigue and the consciousness of failing powers are painfully felt and produce a sensation of oppression or a certain amount of restlessness. It is also true that unadmitted doubts as to one's own worth often cause a correspondingly strong need of recognition from others, and this is expressed in various external ways which are quite incomprehensible to youth—as incomprehensible as miserliness, and the overvaluation of property, faults of age which writers and poets of all ages have scoffed at. Such descriptions of the *senes marosi, anxii, difficiles, iracundi, avari*.

Of the mournful decay which the psychiatrists have portrayed for us and which passes without any sharply defined dividing line into the domain of senile dementia and the psychosis of age form a painful contrast to the serene image of the *lenis placida fortis senectus* which we find in the words and the example of a Goethe or a Jacob Grimm. 'It seems to be the case,' says Grimm, 'that old men take on a certain degree of acidity like old wine, yet we must remember that not every wine gets sour as it gets old' and he continues 'why should the old man do a less amount of work? His storehouses are filled and year by year he has added to their treasures through experience. Ought he to allow his hoarded treasures to fall into strange hands? In gifted and exceptional men strength and endurance long continue almost without any deterioration. To the unabated capacity for work and the undimmed eagerness for research there is added likewise another and a greater advantage, that consciousness of freedom which grows and strengthens with age; when the seeds of freedom have early been planted in a man's heart, when the noble plant that springs therefrom has flourished throughout a long life, how can it but be deeply rooted in the heart of the old man and bear him company to the end?' It is capable of proof, indeed, that the capacity for the production of original ideas develops later and disappears much later than the capacity for assimilating the ideas of others and above all the *power of judgment* is usually retained unaltered, even amidst the intellectual contraction of the horizons of age, and this power of judgment supported by the experience of a long life and less liable to influence by emotion and passion than in youth and, therefore, more just, is what lends its significance to age, making it the proper advisor of creative youth, especially in the domain of public life.

"Michlmann and Ribbert have shown that the physiological death of old age starts with the brain. But this slow extinction of life in consequence of the failing of the functions of the brain is, in fact, a rare exception, since in nearly all cases some disease brings the life of the old person to an end. Hence, the problem of age, so far as the physician is concerned resolves itself into the diseases of age.

"Diseases, whether through infection or traumatism, or through endogenous injuries, are particularly dangerous for old persons because of the lessened resistance of the organism.

"Among other diseases of age we must include arterial sclerosis and cancer, although both appear in younger life, and although it is quite certain that they are not conditioned by age alone. The problem of cancer is one of the obscurest in the science of pathology, as well as one of the most difficult in the art of healing . . . Areteriosclerosis seldom fails to make its appearance in old persons, and it is especially in the circles of men burdened with heavy duties that it seeks its victims. The previous history of the man wreaks its vengeance upon the blood vessels and the heart; every excess of emotion, of work or pleasure, of sorrow and anxiety, leaves its mark upon the arteries. These alterations silently increase in intensity through long years and are first made visible by the failure of the compensation apparatus to function. Thus arteriosclerosis is often the final stage of a process which had already begun in youth."

The address closes with a brief survey as to the aging and final perishing of entire classes of animals and races of men, of peoples and of empires.

Coins of the Ages—I

An Illustrated Description of Greek, Roman, Medieval and Latin Coins with their Histories

By Howland Wood, Curator of American Numismatic Society

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One of the most commonplace articles of our everyday existence is our money, yet how few people know anything about the coins carried in their pockets—their origin, history or meaning. If one should give any thought to the subject, the probable supposition would be that coins are as old as civilized man, so essential are they to our affairs and convenience. Coins are, however, of comparatively recent origin in the history of man. The ancient Babylonians, Chaldeans, Assyrians and Egyptians had no knowledge of stamped money, though in their commercial transactions they made use of gold and silver by weight, and of ingots and rough lumps of metal and gold dust. The purity of the metal could not be vouched for, and each minor business transaction was cumbered with the necessity of weighing the metal, or the process of barter was resorted to.

Great credit should be given to the unknown genius who invented the simple expedient of stamping pieces of metal of given recognized weights and purity. But like many other things that have grown to great importance, the small beginnings are shrouded in obscurity. The actual invention of coinage took place about 700 B. C. Definite credit can be given to the Lydians in Asia Minor for the first gold, or rather electrum coinage, a natural alloy of gold and silver; and to Phaedon, King of Argos at Aegina, for the first silver money. Possible credit can be given to the Chinese as well, as their coinage dates from this time, though they are wont in their numismatic treatises to date their initial coinage nearly two thousand years earlier. It is interesting to note that in the Occident the first money was based on certain recognized weights of gold and silver, and that the pieces so stamped bore their just value, and the mark impressed, though an arbitrary symbol, served as its guarantee, but bearing no indication of weight or value. In the Orient the first coins were made of bronze and were a resemblance in miniature of different objects, presumably standard units of value in bartering. The shape of the piece formed the distinguishing mark, though later names of localities and values were added.

The differentiation between a coin and a rough lump of metal is that the former has a stamp on it, which may be only a mere mark, guaranteeing its weight and purity by some responsible party, preferably a state. A coin has circulating value and may be termed money just as long as it is generally accepted in a given locality.

Coins are one of our best and truest historical documents, though in size the smallest, nevertheless, in reality about the widest in range of all antiquities. Geography, history, the sequence of human affairs, art and mythology are summed up in a study of coins. In fact, archaeologists and historians would oftentimes go astray except for the story coins can tell.

An outline of the history of coins is shown in the accompanying plates, with brief remarks about the pieces. Greek coins of the best period are the most artistic of any age and are eagerly sought after. As will be noticed, most coins up to modern times are religious in their types, though every conceivable design is found on them. Portraiture did not appear until after the time of Alexander the Great. After the fall of the Roman Empire the coinage of Europe became more and more debased, culminating in the end of the twelfth century, when reforms gradually set in. Since the discovery of America, with the large influx of gold and silver into Europe, the coinage again became more plentiful and larger denominations have been minted.

Old coins, however, are not necessarily rare as the issues in former days were generally plentiful, paper money and other modern substitutes not being used. By reason of the lack of banks, money was kept at home or buried in the ground, and the consequence is that coins of all ages are being continually dug up, adding to our knowledge of by-gone days.

The plate of Greek coins is taken from specimens in the British museum, London; the Oriental coins from the collection of the writer, and the other eight plates from specimens in the cabinet of The American Numismatic Society, New York. All coins shown on plates are two-thirds actual size.

Greek Coins.

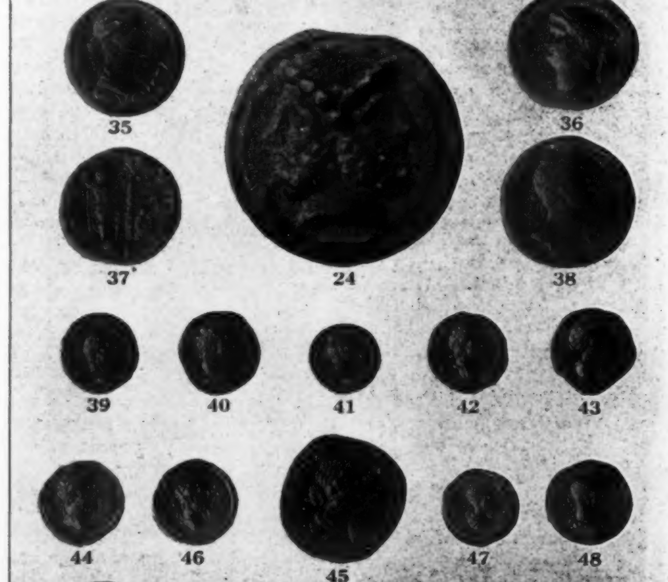
1. Lydia, electrum stater, about 700 B. C. This is considered the earliest known coin. The obverse has simply a striated surface; the reverse, three depressions without much form.

2. Aegina, 7th century B. C. This is the earliest silver coin and is said to have been issued by Phaedon, King of Argos. The sea tortoise is the symbol of Astarte, the Phoenician goddess of trade. The crude depression on the reverse is made by projections set in the bed on which the unstamped coin was placed to keep it from slipping while being struck. Later, regular dies were used to strike both sides of the coin.

3. Syracuse, tetradrachm, about 480 B. C. Early, fine style. The head is of the nymph Arethusa surrounded by dolphins. The other side commemorates the Olympian victory of Gelon.

4. Metapontum. The spike of wheat is typical of the coins of this city and refers to the fertility of the district. The other side has the same design

Greek Coins



Roman Coins

but intaglio, a peculiarity common to the early coins of the Greek cities in Italy.

5. Persia, gold daric. This is the common type for many years of the coins of the Persian kings.

6. Samos, silver coin of fine style of the latter end of the 5th century B. C. The lion scalp and the ox are common devices on Greek coins.

7. Gela, silver tetradrachm of the tyrant Gelon (see 3) showing the badge of the city, a man-headed bull.

8. Athens. The famous Athenian tetradrachm current throughout the Greek world, showing the head of Athena with her owl and olive branch. The archaic style of all of these coins is on account of the fact that any improvement in the looks of the coin would have precluded its wide circulation.

9. Gortyna in Crete. Europa seated in a tree. The unconventional subjects of many of the Cretan coins are remarkable.

10. Agrigentum. A most beautiful coin showing two eagles devouring a hare. The quadriga on the reverse is common to Sicilian coins.

11. Naxos. This beautiful silver coin bears the head of Dionysus on one side and Silenus with a wine cup in his hand on the other.

12. Amphipolis. The charm of this facing head of Apollo must make anyone feel that our modern coins are but mediocre expressions of art.

13-14. Alexander the Great. The type of his silver coinage showing the head of Herakles and the seated figure of Zeus on his throne; and (14) the gold stater showing the head of Pallas and Nike or Victory.

15. Syracuse, dekadrachm or ten drachms. One of the largest and most beautiful of Greek silver coins. It is signed by the artist Evaenetos and bears the head of Persephone. The action and spirit of the horses are worthy of note.

16. Tarentum, gold coin of Alexander of Epirus, showing the head of Zeus and the thunderbolt.

17. Demetrius Poliorcetes. This coin refers to the naval victory of Antigonus, under his son, Demetrius, over Ptolemy, off the island of Cyprus in 306 B. C. The statue on the prow of the ship is the Victory of Samothrace in the Louvre.

18. Pergamos. A coin struck by Attalus I. showing the portrait of his uncle, the eunuch Philetaerus, the founder of the dynasty.

19. Syria. A portrait coin of Antiochus III. the Great.

20. Syracuse. A tetradrachm showing the portrait of the beautiful Queen Philistis.

21. Antigonus Doson. Head of Poseidon. and Apollo seated on the prow of a galley on the reverse.

22. Syria. Portrait coin of the youthful Antiochus VI. B. C. 145-142.

23. Jerusalem. The type of the famous Jewish shekel. The inscriptions say "Shekel of Israel" and "Jerusalem the Holy."

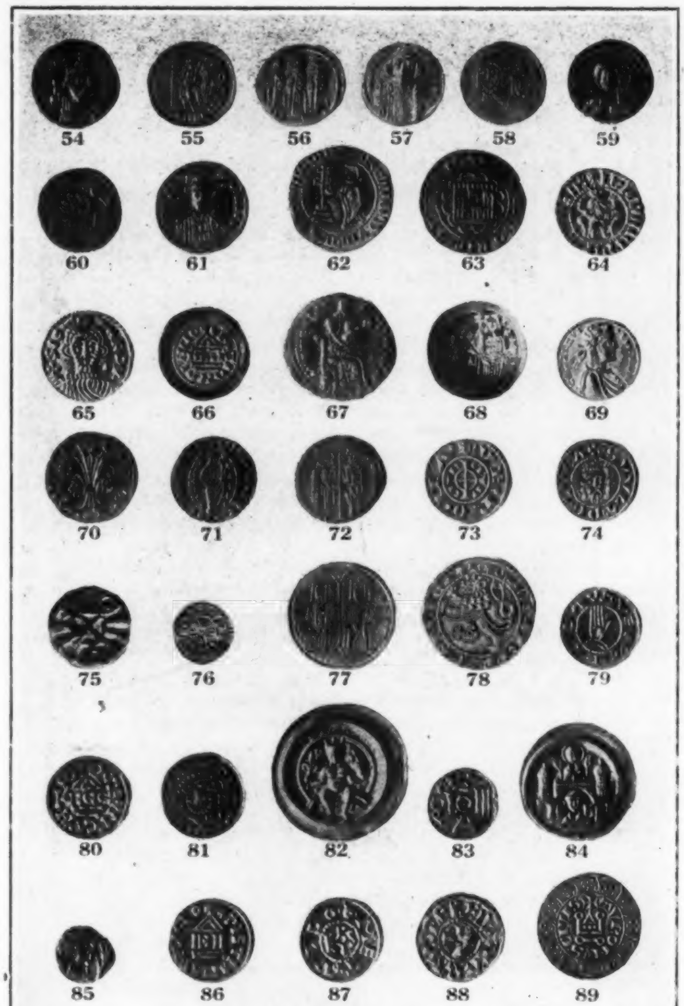
ROMAN COINS

The earliest coins of central Italy were rough lumps of bronze, which were later followed by rough rectangular slabs with crude representations of animals, etc., on them, and weighing several pounds. How much this latter was a true coinage is open to doubt. The real coinage began about 338 B. C., with the large round cast coin of bronze weighing 10 ounces or less.

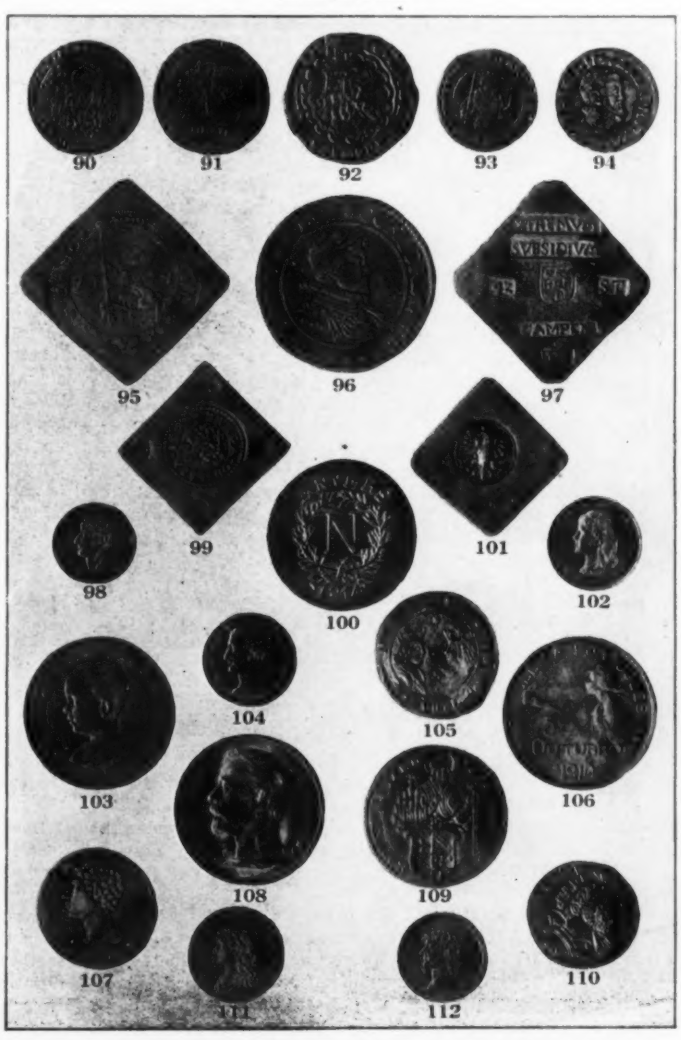
24. An aes or as, of the early period. This denomination always bore the head of Janus, and the specimen shown here weighs nearly 9 ounces. The subdivisions each bore different heads.

25. The Roman semis, or half, of a later period, with the weight reduced. It bears the head of Jupiter.

26. The reverse type of all the early Roman Republic bronze coinage, showing the prow of a ship. The Roman boys in tossing up coins were wont to call out heads or ships, as we say heads or tails.



Medieval Coins



Coins of the Low Countries, Spain and Italy

The Roman silver money began about 268 B. C., and for the most part was of the denomination of a denarius, though different subdivisions were minted.

27. Shows a quinarius of the first and commonest obverse type of the series, which bears the helmeted head of Rome. Later various designs and portraits were adopted.

28. The earliest type of the reverse, the Dioscuri. After 150 B. C. various types were introduced, injecting a great interest and variety into the series. The piece is a denarius.

29. Denarius, showing portrait of Caesar veiled in the character of Pontifex Maximus. Although portraits of ancestors had now and then been placed on the coinage by the different moneyers, Caesar's was the first actual portrait to be placed on Roman money. This innovation the Senate itself ordered in 44 B. C. The inscription, *Dictator Perpetuo*, noted on the coin was conferred on Caesar the same year. The name of the moneyer, Publius Sepullius Macer, also occurs on the coin.

30. Denarius, struck by Sextus Pompey while defying the Roman Senate in Sicily, 42-38 B. C., and bears the head of his father, Pompey the Great.

31. Denarius, bearing the portrait of Mark Anthony, probably struck at Ephesus about 41 B. C. while he was living a dissipated life in the East. The reverse has the head of young Octavius (not shown).

32. A similar coin showing the bust of Cleopatra. On the other side is the bust of Anthony. This piece was probably struck at Athens after the Roman Senate had declared war on Cleopatra. The legend is interesting and may be translated "Coin of Cleopatra, Queen of Kings, and of her Sons, the Kings."

33. A denarius of Octavius with his title of Caesar Augustus.

34. An aureus or gold coin of the Emperor Tiberius, struck in 15 A. D.

35. A bronze coin known as a dupondus, bearing the head of Livia, the mother of Tiberius.

36. A bronze coin called a sestertius, showing a fine portrait of the Emperor Nero.

37. The reverse of a sestertius of Vespasian with inscription Judaea Capta and showing the Emperor standing in military costume, and the personification of Judea weeping, seated against a palm tree. This coin commemorates the triumph over the Jews.

38. A nice portrait coin of the Emperor Hadrian, struck in 118 A. D.

The following coins are shown for their fine portraits of some of the Emperors and their wives: 39, Vespasian; 40, Domitian; 41, Trajan; 42, Antonius Pius; 43, Faustina, Sr., wife of Antonius; 44, Marcus Aurelius, as Emperor; 45, Faustina, Jr., the wife of Marcus Aurelius; 46, Septimus Severus; 47, Geta as a young boy; 48, Severus Alexander at about the age of 23.

The coinage of Rome from now on shows a decided falling off, the portraiture is poorly done and the decline of the Empire is all too apparent.

49. Maximianus Hercules; 50, St. Helena, the mother of Constantine; 51, Constantine, the Great; 52, Julian the Philosopher or the Apostate; 53, Theodosius I.

MEDIEVAL COINS

After the fall of the Empire in the West, the Eastern, or Byzantine, kept on for several centuries and issued coins, chiefly gold and copper. In fact, they largely supplied Europe with gold coins and furnished the prototypes for most of the coins of the barbarians that settled in the old Roman domains. The workmanship of the coins is now very inferior and true portraits are a thing of the past.

54. A gold solidus of the Byzantine Emperor Phocas, struck at Constantinople, between the years 602 and 610.

55. The usual type of reverse of many of the earlier Byzantine gold coins. This was copied very largely by the different barbarian nations.

56. A solidus struck in 641, showing the Emperor Heraclius I. and his two sons, Heraclius Constantinus and Heracleonas. This coin was used as a model by the Arabs on one of their gold coins.

57. A solidus of Constant II., interesting on account of his long beard.

58. A coin of the Emperor Theophilus, showing portraits (?) of his father, Michael II., and his son Constantine (832-839).

59. A solidus of Constantine VII. (945-959) with the bust of Christ. The head of Christ made its first appearance on coins about 300 years before, during the reign of Justinian II.

60. A silver coin, known as an asper, of Manuel I., Emperor of Trebizond, an offshot of the Byzantine Empire. Although most crudely done, these coins had wide circulation.

61. A barbarian imitation of a Byzantine solidus of Justinian I., probably made by the Burgundians.

62. A silver coin known as a "gigliati," struck in the first half of the 14th century by Helion de Villeneuve, one of the Grand Masters of the Order of St. John of Jerusalem, at Rhodes.

63. A silver coin struck by Roemond VII. (1274-1287), Count of Tripoli, in the Holy Land. As is well known, the Crusaders set up a number of kingdoms and principalities in the East and issued coins for many years.

64. Armenia, a silver coin called a tehegan, issued by Leo II. (1185-1218) at the time when Armenia was a separate and independent kingdom. The inscription is in Armenian characters.

65. Beneventum in Southern Italy, a gold coin of one of the Lombard dukes, Sicardus, 833-839. Note the coarse copying of the Byzantine coins. (See No. 54.)

66. A denaro, or thin silver coin, struck at Milan about 900 by Berenger of Friuli, one of the Carlovingian kings of Italy. This type of coin, showing the crude outline of a Greek temple, was much in vogue during the middle ages. (See 80 and 86.)

67. A copper follaro struck by Roger (1058-1101), one of the Norman counts that drove the Arabs out of Sicily. A crude representation of the Madonna is shown on the piece.

68. A concave silver of Roger II., King of Sicily. This piece was struck at Brindisi in 1140. The word ducat originated from the coinage of a duke and is generally in gold.

69. The famous gold augustale of the Emperor Frederick II. of the Hohenstaufens, struck in 1232 at Brindisi. This was patterned after the Roman coins, and in design and execution was several centuries ahead of the rest of Europe.

70. The Florentine florin, so named from the flower (lily) engraved on it. It was first made in the 13th century and had a wide circulation throughout Europe, where it was extensively copied.

71. The zecchino or sequin of Venice, as famous a gold coin as the florin. This had a wide circulation in the East and is occasionally met with today.

72. The Venetian grosso. This type of silver coin was made for several centuries and clearly shows its Byzantine influence.

73. A grosso of Verona. The cross is one of the commonest devices used on the coins of the Middle Ages and is generally placed on the reverse.

74. The Santus Vultus of Lucca, a type very commonly used for this city.

75. A pfennige struck by the Wends, early inhabitants of East Prussia, a crude copy of the general type of coins at the time with a cross on it.

76. A denar of Andreas I. of Hungary, 1046-1060. Many of the early Hungarian coins were small like this.

77. A copper coin of Bela IV. of Hungary, 1235-1270, showing strong Byzantine influence.

78. The prager groschen of Bohemia, introduced by Wenzel II. early in the 14th century. A coin that was copied extensively.

79. A peculiar and interesting type of Bohemian coin; hands and other devices are frequently found on coins of this country.

80. A denier struck at Regensburg by Henry III. of Germany, 1039-1056. This type of coin was very popular. (See 66 and 86.)

81. Another common type of German coin struck by the same Emperor.

82. A bracteate struck by the Emperor Frederick I. of Germany. This sort of coin was very common in Central Europe about the 12th century, and was stamped on one side only on the thinnest sheets of silver. The metal is but little thicker than two sheets of the paper this book is printed on. The reverse is an intaglio of the obverse.

83. A common type of denier struck at Cologne in the 12th and 13th centuries. *Colonia* is the Latin form of the name of the city.

84. A bracteate struck by Gardolf von Harbke, Bishop of Halberstadt, at the end of the 12th century.

85. A gold triens struck in France by the Merovingian king, Sigebert II., 638-656. Greek, Roman and Byzantine coins served as the models for the coins of France at this time.

86. A denier of the "temple" type, struck by the Carolingian king, Louis I. (814-840).

87-88. Obverse and reverse of a denier struck by Charles the Bald (840-877) of France. On the obverse, his name in monogram in the center. The reverse (88) with the cross is almost the stereotyped form for this side of the coin.

89. The gros-tournois of France, first struck by Louis IX. (1250-1270), which was extensively imitated in Western Europe. Note the survival of the temple device.

Coins of the Low Countries, Spain and Italy

90. A Pierre d'or of Jeanne and Wenceslas of Brabant, struck at Louvain in the last part of the 14th century. Coins were often named from the device on them, St. Peter being on this coin.

91. A gold cavalier or rijder, struck at Antwerp by Philip the Good of Burgundy. Knights in armor were often depicted on the coins of the Low Countries.

92. A lion double gros, struck by Louis II. de Mâle (1346-1384), Count of Flanders. This is a common type of silver coin.

93. A gold real struck by the Emperor Charles V. at Bruges for Flanders. As Charles V. inherited nearly all of Europe, coins bearing his name were struck in nearly every country.

94. A tenth ecu struck at Utrecht for the Netherlands by Philip II. during the time of the Spanish dominion.

95. A daalder struck at Leyden in Holland in 1574 during the first siege by the Spaniards. In those days sieges were commonly of long duration and the beleaguered cities were often sorely pressed for money and struck crude coins as best they could, very often from church plate and the silver dishes of the more wealthy townspeople.

96. A dollar struck by the United Provinces at Dordrecht in 1586, bearing the head of the Earl of Leicester, during the time of the English aid to Holland.

97. An obsidional or siege coin struck at Campen in 1578 while besieged by the troops of the States.

98. A gold ducat struck in 1809 by the Kingdom of Holland under Louis Napoleon.

99. A coin of the siege of Breda in 1625.

100. A copper coin for ten centimes struck by the Napoleonic forces in Antwerp while besieged by the Allies in 1814.

101. Half daalder struck in Deventer during the siege of 1672 by the Bishop of Münster and the French.

102. Ten gulden gold coins of Wilhelmina of the Netherlands. While she was a girl the portraits on the coins were changed every few years as she grew up.

103. A Spanish coin with the baby head of the present king.

104. Joseph Napoleon as King of Spain on an 80 real piece.

105. A double excelente, a gold coin showing Ferdinand and Isabella of Castile and Leon.

106. The new escudo piece of the Republic of Portugal.

107. A portrait testone by Benvenuto Cellini of Alexander I. Medici, of Florence.

108. A 100 franc piece of Monaco. The coins of this little principality are used largely in the gambling halls of Monte Carlo.

109. Doblone struck at Bologna while under the Popes, by the Dominican Brothers, during a famine in 1529.

110. Dobla of Charles V. struck at Naples in commemoration of the pardon granted the Neapolitans after the insurrection against the Inquisition.

111. A 20-franc piece struck at Turin in 1800 by the newly formed Republic of Subalpine Gaul to commemorate the battle of Marengo.

112. A 20-lire piece struck by Murat, brother-in-law of Napoleon, while King of Naples.

Temperatures in Deep Mines.

An interesting communication from Mr. E. H. Clifford, of Johannesburg, on the subject of "High Temperatures in Deep Mines" was read at a recent meeting of the Midland Institute of Mining Engineers. In his letter Mr. Clifford describes the conditions prevalent in the City Deep Mine.

At the present time the workings, which are confined to the uppermost portion of the mine, extend over an area of approximately 100,000 ft. along the strike by 3,500 ft. on the dip, and the greatest vertical depth at present is 4,500 ft. On the Witwatersrand the temperature of the rocks increases at the rate of 4 deg. for every 1,000 ft. in depth, and the rock temperature at 4,500 ft. is 84 deg. This would not be at all serious were it not for the fact that the air, shortly after leaving the main intakes, very soon becomes saturated in consequence of regulations stipulating that all rock surfaces should be kept wet in order to prevent the dissemination of dust. A saturated air at a temperature of 84 deg. Fah. is scarcely supportable unless the air was in active motion.

They had therefore reached the limit on the City Deep, and had yet an additional 2,500 ft. to go when the new shaft is completed, and were faced with the necessity of reducing the air temperature from between 95 and 100 deg. Fah.—which it would be at 7,000 ft.—to about 75 deg. Fah. The principle that was being relied upon was the heat-absorbing capacity of the ventilating current of air due to evaporation and to its specific heat. Local cooling near the bottom of downcast shafts was, of course, taking place everywhere, but it generally remained local cooling only, and in any case could have little or no effect on the temperature of distant parts of the mine, unless the total heat absorbed by the air current as a whole was greater than the heat supplied from all sources. In the City Deep there was no difficulty with temperatures down to a depth of 4,500 ft., but whether the principle would be equally successful at 7,000 ft. remained to be seen.

The heat of the air in the mine came from the following sources:—(1) The compression of air on its way down the shaft. This was considerable; in fact, the temperature rise on this account was actually greater than the temperature rise of the rock due to depth. (2) The flow of heat from the rock mass to the air of the workings. (3) Further sources of heat are water, the men working in the mine, the combustion of illuminants, explosives and electric power. A frequent source of heat supply, viz., chemical change of minerals, is not, in the case of Witwatersrand, of any importance. To absorb this heat they were relying upon:—(1) The specific heat of the air, and (2) the heat absorbed by its evaporative power. It is very fortunate that in the Transvaal the air during the greater part of the year is dry, the percentage of humidity ranging between 74 per cent. during the rainy season and about 36 per cent. during winter. The capacity of the fan is 400,000 cubic feet per minute, and the average heat-absorbing power of this quantity of air is 1,700,000 calories per second. Of this amount one-fifth is due to the specific heat of the air and four-fifths due to evaporation. On account of the dynamic heating practically the whole of the heat-absorbing capacity resulting from the specific heat is lost in the deepest parts of the mine, but as the air rises to the shallower parts of the mine some of this is returned. In the calculations the abstraction of 1,360,000 calories per second is all that can be relied upon. The items under the heading (3) amount to about 185,000 calories per second, leaving a balance of roughly 1,200,000 calories per second available for absorbing the heat from the rocks. Assuming that the mine was bounded by an infinite mass of rock, and assuming that the estimate of conductivity, which was based on experiments, of 0.0093 was correct, this quantity of heat was greater than the heat flow from the rocks to an air current at a temperature of 75 deg. Fah. In the present conditions, therefore, the mine would tend to become cooler as a whole, but the continuous increase in the extent of the mine was having the opposite tendency.

The process is self-regulating to a considerable extent, because the heating of the air increases its evaporative power, and there is abundant moisture everywhere for the exercise of this power, and also in consequence of the dynamic cooling as the air travels from the lower to the upper parts of the mine. One further effect of the fall of temperature is to bring about a condensation of moisture, making the air extremely foggy in the upper parts of the mine, and it has this incidental advantage that the air becomes completely cleared of dust.—From *The Engineer* (London).

Rectifying High-Tension Alternating Currents*

Experiments With a Gap Between a Point and a Plate

By Samuel Cohen

During the year 1914, while experimenting with spark gaps for use in radio-transmitting apparatus, which were to be supplied by high-tension unidirectional currents, the writer found a new method by which to obtain these currents. Although these high-tension currents were utilized for radio work, yet they can be used with equal success for other purposes where such currents are desired, as, for instance, in operating electrical precipitators, X-ray tubes, etc. The only available rectifying apparatus for voltages exceeding 5000 volts are at present those of the synchronized rotating commutator and kenotron vacuum valve. Another method of obtaining a partial rectification of a high-tension discharge consists in passing a current from a point to

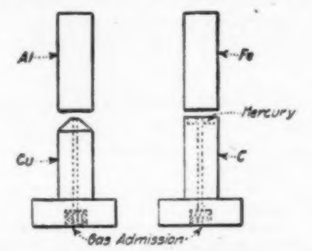


Fig. 1. Electrode construction used in experiments

a plate. This process has been known for a long time, but the commercial application of the principal was unsuccessful owing to its inconsistency and poor operating efficiency. But the rectifier, when properly constructed and when its discharge medium is subjected to a gas under pressure, will be found to yield high efficiency and satisfactory consistency of operation. An efficiency of 85 per cent was obtained by the use of NH_3 under a pressure of about 100 lb. per square inch (7 kg. per sq. cm.), and successful operation was obtained by using an iron point and a rotating aluminum disk. It is thus the purpose of this article to give a short detailed description of some of the results and a description of the apparatus used in the experiments.

The rectifying apparatus consists of a chamber within which there are two electrodes made as shown at the left in Fig. 1. The upper or movable electrode was made from aluminum, ⅝ in. (1.6 cm.) in diameter. The lower or fixed one consisted of a copper rod of the same diameter and with its end turned conically as shown. Through the center of this copper electrode a small hole was drilled and used to allow gas to pass through and strike the upper electrode. When these electrodes were connected to the secondary terminals of a high-tension transformer and in series with a direct-current am-

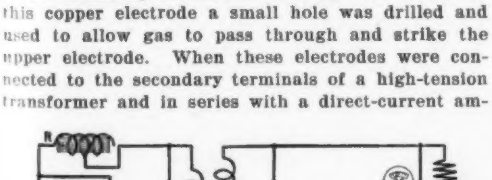


Fig. 2. Arrangement of apparatus for high-tension rectifier

meter and a load resistance it was found that the meter would indicate the presence of the rectified current. However, it was observed that the current was not steady enough, owing to the poor cooling of the electrodes, as the conical point began suddenly to wear away.

This trouble was remedied by admitting into the axial opening of the lower electrode air under various pressures, and it was immediately found that the rectified current became steady and the value of the current increased many times the value noted prior to the admission of the gas.

Air First Used at the Arc

The next step was to ascertain the effect of various pressures of the admitted air on the efficiency of the apparatus in reference to the rectified alternating current. In obtaining the data for this experiment the apparatus were connected as shown in Fig. 2, where a 60-cycle, 110-volt alternator is shown connected to a 20,000-volt transformer through a variable reactor, *R*, in the primary circuit. A voltmeter, *V*, and a wattmeter, *W*, were also connected in the primary circuit. The secondary of the transformer was connected to the rectifying discharger, *D*, through a specially made direct-current ammeter, *A*, load resistance *LR*. An electrostatic voltmeter, *V*, and a safety spark gap, *SG*, were shunted across the secondary leads. The distance between the electrodes was kept constant throughout the test at about ⅛ in. (3.2 mm.). Various pressures from 0 to 200 lb. per square inch (14 kg. per sq. cm.) were admitted, and the efficiency of rectification with respect to primary input power was noted. The curve marked "air" (Fig. 4) gives the results obtained from this experiment. It is seen that the efficiency of rectification is quite low at lower pressures, and between 150 lb. and 170 lb. per square inch (10.5 to 11.9 kg. per sq. cm.) the best results were obtained with an efficiency of practically 75 per cent. Although the figure seems to be a rather high rectifying value, it was impossible at the time to carry out more precise work for verification owing to the unsuitable equipment used in all these investigations. Yet the values appear very consistent, as they were checked several times.

Other Gases Are Investigated

Carbon-dioxide (CO_2) was the next gas under investigation, and it was found that maximum rectification was noted at less pressure than that obtained for about the same percentage of input current. From the curve it will be noted that 90 lb. per square inch (6.3 kg. per sq. cm.) was the value observed for maximum rectification. From the slope of the curve it will be noted that rectification increases rapidly with the increase of pressure up to 80 lb. (5.6 kg. per sq. cm.), and decreases very slowly from 100 lb. down to 180 lb. (7 kg. to 12.6 kg.).

Although this gas gave favorable results, it was found that long periods of operation of the rectifier decreased its efficiency. As carbon-dioxide in a short spark field decomposed to a certain extent and created a carbon film on the surfaces of both electrodes, it thus increased the resistance of the discharge and hence decreased its efficiency. It was found at times that absolutely no rectification was observable due to the excess carbon film adhering to the electrodes. It was thus necessary to clean the electrodes carefully in order to continue the investigation. One advantage in favor of this gas is stability of operation.

Sulphur-dioxide (SO_2) was also tried, and it was possible to obtain a much higher percentage of rectification with the same amount of primary-power input in the primary transformer circuit than that obtained by the use of carbon-dioxide. However, the difficulty with the use of this gas is somewhat the same as with the former, since the sulphur-dioxide decomposed into its elements, sulphur and oxygen, causing a collection of sulphur film upon the surfaces of the electrodes, which caused the increase of resistance of the spark field. This decreased its overall efficiency. Sixty per cent was the maximum percentage of rectification that could be obtained by the use of this gas at 120 lb. per square inch (8.4 kg. per sq. cm.) as indicated in Fig. 3.

By this time the writer was fully convinced of the difficulty of using this type of high-tension rectifier, namely the instability of the apparatus after long periods of use.

Ammonia Proves Efficient Medium for Rectification

Other means were then tried in order to make the instrument more stable for continuous periods exceeding five hours. Various cooling devices were applied to the electrodes in order to accomplish the results. Finally ammonia under pressure was passed through the rectifying gap in the same manner as were the others. The cooling effect of the gas during expansion was utilized to advantage in this apparatus, and not only was it found to act as a cooling agent, but at the same time it was found that the percentage of rectification was greatly increased as compared with gases previously used, and it will be noted from Fig. 3 that as high as 85 per cent efficiency was obtained with ammonia gas at 100 lb per square inch (7 lb. per sq. cm.). Most remarkable stability was obtained with this gas for periods up to ten hours' duration. Results were noted at half-hour periods and it was found that the variation of rectified current did not exceed 1 or 2 per cent. There are two reasons why ammonia proved much more efficient than other gases, namely, (1) the electrodes are kept cool, thus preventing a vaporization of the spark electrodes due to the intense heat of the spark or arc field; (2) the spark field is inclosed in an atmosphere of nascent hydrogen, which has the remarkable effect of increasing the spark field. In this disintegration of the ammonia into its constituent elements of nitrogen and hydro-

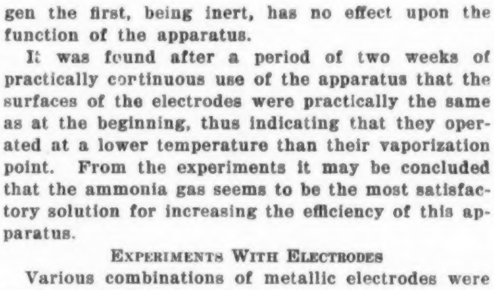


Fig. 3. Efficiency of rectifier with various gases

gen the first, being inert, has no effect upon the function of the apparatus.

It was found after a period of two weeks of practically continuous use of the apparatus that the surfaces of the electrodes were practically the same as at the beginning, thus indicating that they operated at a lower temperature than their vaporization point. From the experiments it may be concluded that the ammonia gas seems to be the most satisfactory solution for increasing the efficiency of this apparatus.

Experiments With Electrodes

Various combinations of metallic electrodes were tried, and it was found from actual experiments that a combination of aluminum and copper gave most suitable results. The next investigation undertaken was to determine the effect of mercury in a hot spark field, in a gas atmosphere, and to note the rectification obtained by the use of this metal. Difficulty at first was had in constructing the mercury electrode so that the admitted gas would not disturb the mercury from its position during operation, and Fig. 1 (right) shows a method utilized for accomplishing this result. A circular groove was made in the lower electrode so that the gas opening did not come in contact with this groove, thus avoiding con-

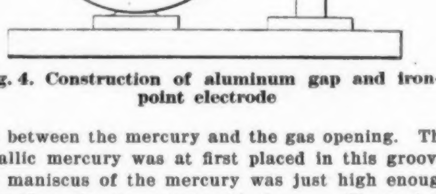


Fig. 4. Construction of aluminum gap and iron-point electrode

tact between the mercury and the gas opening. The metallic mercury was at first placed in this groove. The maniscus of the mercury was just high enough to avoid coming in contact with the gas. The various gases as utilized in the previous rectifier were utilized with this form of rectifier and ammonia gas proved again most effective. However, the difficulty experienced in the use of this rectifier was that of partial short-circuiting of the electrodes, due to the partial vaporization of the mercury, thus preventing momentarily the operation of the device. During these periods it was found necessary to increase the admitted gas pressure in order to avoid this excess vaporization. It was necessary, however, to reduce the pressure in order to obtain maximum rectifica-

* From the *Electrical World*.

tion. The critical gas pressure for obtaining this maximum rectification was noted to be the same as when used in the previous rectifier, namely, 100 lb. per square inch (7 kg. per sq. cm.).

The only advantage favoring the use of mercury as an electrode was that of constant stability at overload for short periods. For longer periods of overload, however, the device failed to perform its functions, owing, perhaps, to the short-circuiting of the electrodes with mercury vapor.

The only disadvantage experienced in the use of aluminum as one of the electrodes was that of pitted surfaces noted at its operating surface. This was undoubtedly due to the low melting temperature. It was found from actual experience that as soon as the aluminum surface began to pit the efficiency of the instrument was considerably lowered and it was thus necessary to face down its working surfaces every time this efficiency decreased. In order to avoid this detrimental effect, it was necessary to use a rotating aluminum disk so as to give a new sparking surface at all times during the operation of the instrument. Fig. 4 shows the construction of the instrument used. The aluminum disk was rotated by a motor.

In this case an iron-pointed electrode was utilized for the second electrode, and the admitted gas was passed through the cylinder as indicated. The insulated knob was fastened to the iron-pointed electrode to allow of gap adjustment between the aluminum disk and the pointed electrode. Very satisfactory results for continuous operation were obtained with this instrument, and it is the only means by which satisfactory results were obtained for continuous operation in rectifying high voltages. The investigation has by no means been completed. Further investigation will be made and additional data on this subject will be given in the near future.

The Anay, a New Edible-fruited Relative of the Avocado.

By S. F. Blake, Bureau of Plant Industry.

One of the most interesting results of the explorations in search of new and desirable avocados and related fruits, carried on in Central America for several years past by Wilson Popenoe, of the Office of Seed and Plant Introduction, is the discovery of the anay. Guided by the reports of natives, Mr. Popenoe first met with the species on September 23, 1916, when two trees were found at the entrance to the Finca El Compromiso, half a mile from Mazatenango, Guatemala, at an elevation of about 365 meters. Other trees were known to the natives in the nearby forest, and were visited by them at the proper season to secure the fruit. The two trees seen by Mr. Popenoe had been left to provide shade for young coffee trees when the forest was cleared. They were about 22 meters high, with the tall and slender turnk bare of branches for a considerable distance, and an open rounded crown. On this occasion Mr. Popenoe, being unable to find a native venturesome enough to climb the trees, had to content himself with pieces of the bark and with some of the fruits, which were lying in profusion on the ground. He also secured leaves from sucker shoots at the base of one tree, but comparison with specimens secured from the same tree on a later trip shows that these belong to some other plant.

The fruits of the anay, which ripen in August and September, are very similar in external appearance to those of certain types of avocado (*Persea americana*). They are 10 to 15 cm. long, ellipsoid-pyriform, sometimes curved, sometimes pointed at apex, often with sharply defined neck, with the body slightly compressed, and smooth, glossy, purplish black surface. The skin is very thin and membranous, adhering closely to the firm, oily, rather scanty flesh. This is divided into two zones of color, equal in thickness, the outer pale green, the inner greenish cream-color, both being more sharply defined than is ordinarily the case in the cultivated avocado. The flesh has a rich, bland flavor, like that of a very good avocado, but faintly sweetish. The large, abovoid seed, with the pointed end toward the base of the fruit, has a thick, almost fibrous, outer seed coat and a membranous inner one closely including the cotyledons, but not always reaching to their apex. The pubescent plumule lies immediately at the base of the cotyledons, while in the avocado it is located some distance above this point. The fruits fall while still hard, ripening in two or three days, and germinating freely on the ground beneath the parent tree. Most of the specimens found by Mr. Popenoe had been attacked by insects, which tunneled through the seeds.

The notes from which this description of the fruit has been drawn up were made by Mr. Popenoe on his first visit to the trees. On a later visit, on January 17, 1917, a mozo was found who ascended one of the trees by means of a nearby palm and threw down branchlets with leaves, young fruit and a very few flowers. Study of these shows that the anay is not a *Persea*, as Mr. Popenoe at first supposed, but an undescribed species of the genus *Hufelandia*, which is at once distinguished from the avocado (*Persea americana*) and its near relatives by the fact that the anthers are 2-celled instead of 4-celled.

Since collecting the anay at Mazatenango, on the west coast of Guatemala, Mr. Popenoe has found it at Chamà, on the Rio Chisoy in the Usumacinta basin in Alta Verapaz, northeastern Guatemala, at an altitude of about 300 meters, although no specimens were obtained. It is the belief of Mr. Popenoe that the name of the old Maya settlement Anaité, farther north in the same valley near the ruins of Menché Tinamit and Yaxchilan, has reference to the former abundance of the anay in the same region.

The anay, both in the vicinity of Mazatenango and in the Usumacinta Valley, grows in moist regions at an elevation of only 300 to 365 meters. For this reason Mr. Popenoe believes that it will not succeed in California, but that it may do well in southern Florida. Young trees grown from seeds collected by Mr. Popenoe are now cultivated in the Plant Introduction Garden at Miami, under the Seed and Plant Introduction number 43,432, and their future will be watched with much interest. In its native haunts the species was reported by natives to flower in May, but from the specimens collected by Mr. Popenoe it is clear that the flowering season is December and January. The fruit ripens in August and September.—From *Jour. of Wash. Acad. of Science.*

Hints for Electric Welders.

In notes designed for instruction in electric welding by H. L. Unland occur certain suggestions which are worth repeating.

When carbon electrodes are used in arc welding the average length for efficient work should be from 9 to 12 inches. Metallic electrodes of low carbon steel should be about 18 inches long. At least 15 feet of extra flexible cable should be used to allow the operator full control of the electrode through the welding process.

Doubt is often expressed as to the current required for certain types of work. In general in the case of light work where the metallic electrode is used a current not greater than 125 amperes is necessary, while heavier work will stand 225 amperes without burning the electrode. Plates of ¼-inch require 125 amperes. Heating with the carbon electrode necessitates the use of greater currents; light welding, 150 to 250 amperes; heavy welding and medium cutting, 400 to 600 amperes; very heavy work, 600 to 1,000 amperes.

Flux is not necessary to good arc welding and has a tendency to contaminate the weld if used. With the metallic electrode the work should be cut sharp—not over ⅛-inch in length. The current should be held within the limits suggested. Excessive current causes burnt or porous metal to be deposited.

In welding a seam the electrode should be moved in a circular path, advancing along the seam. The metal will adhere only to the surface actually played on by the arc, so care must be taken that the entire surface is covered.

The electrode must be connected with negative terminal, as it is difficult to maintain the arc with the polarity reversed. In starting the arc the electrode should be just touched to the arc and immediately withdrawn to the proper distance.

When welding with the carbon electrode an arc 1 to 1½ inches is the average, but in cutting it should ony be ½-inch.

The eyes of the welder should be thoroughly protected by a mask from the light of the arc, or serious burns to the interior of the eye will result. No chinks or holes in the mask should be permitted, since only a brief exposure of the eye is required to bring on painful results. The inside of the mask should be kept painted dull black to prevent reflection of the light from behind.—From *International Marine Engineering.*

Boring for Oil in Scotland.

After more than two months' preliminary work the actual sinking of the bore which is being put down for oil at West Calder, in East Lothian, has been started, and the fitting up of the plant necessary for boring at another part of the shale and coal fields of the Lothians—near Dalkeith—has also been begun.

At West Calder the bore is being sunk through deposits of coal, shale and water. It is expected that the work will progress at a rate of about 40 ft. a day. Operations will be carried on in two shifts a day, each of 12 hours, so that there will be no interruption of work. Down to a depth of 650 ft. the bore will be 19 in. in diameter, less the thickness of the necessary casing. Afterwards, to a depth of 1,500 ft., the diameter will be 15½ in., then between 1,500 ft. and about 2,200 or 2,300 ft. it will be 12½ in. At any further depths that may be found necessary the diameter will decrease at a somewhat corresponding rate. It may be added that the experts who selected the position of the bore at West Calder are the same as were responsible for the selection of the position at Hardstoft, in Derbyshire. *Times Engineering Supplement* (London).

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